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MAUNA KEA III: METABOLIC EFFECTS OF DIETARY CARBOHYDRATE SUPPLEMENTATION DURING EXERCISE AT 4100 M ALTITUDE

US ARMY RESEARCH INSTITUTE OF ENVIRONMENTAL MEDICINE
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CHO). The EX + CHO group consumed an average of 404 g CHO/day compared to 187 and 159 g CHO/day for the EX and SED groups respectively. The EX + CHO group displayed a higher exercising respiratory exchange ratio (0.81 ± 0.01 vs 0.77 ± 0.01), lower blood and urine beta hydroxybutyric acid and averaged 12.5% greater voluntary miles run over the course of the 4 day study. The ~~results of this~~ study results confirm and extend previous studies suggesting that carbohydrate supplementation is beneficial during strenuous exercise at high altitude.

HUMAN RESEARCH and DISCLAIMER STATEMENTS

Human subjects participated in these studies after giving their free and informed voluntary consent. Investigators adhered to AR 70-25 and USAMRDC Regulation 70-25 on Use of Volunteers in Research.

The views, opinions, and/or findings contained in this report are those of the author(s) and should not be construed as an official Department of the Army position, policy, or decision, unless so designated by other official documentation.

REPORT NO T12-87

Mauna Kea III: Metabolic Effects of Dietary Carbohydrate Supplementation During Exercise at 4100 M Altitude

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FOREWORD

This study was conducted in July, 1985 by the Department of Clinical Investigation, Tripler Army Medical Center with financial support by the U.S. Army Medical Research and Development Command. Logistical support was provided by the U.S. Army Western Command, Ft. Shafter, HI and the 25th Infantry Division, Schofield Barracks, HI.

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ABSTRACT

Twenty-nine male soldiers were divided into three groups to study the effects of exercise and carbohydrate supplementation on physical performance and metabolism at high altitude. All groups were provided a standard military field ration (Meal, Ready-to-Eat) containing 45% carbohydrate (CHO) which was consumed ad libitum during 4 consecutive days of residence at an altitude of 4100 M. Two groups (EX and EX + CHO) exercised while at high altitude by running and walking at ~ 75% maximum heart rate 2h/day. The third group (SED) remained sedentary while at high altitude. One exercise group (EX + CHO) was permitted to consume carbohydrate sweetened beverages ad libitum as a supplement (250 - 350 g CHO/day) to the diet. The other two groups (EX and SED) consumed similar beverages containing a non-caloric sweetener also on an ad libitum basis. Baseline measurements of food consumption, aerobic capacity, and blood and urine metabolites were recorded for all groups during 2 days of sedentary activity at sea level prior to rapid ascent to altitude (4100 M). Mean daily caloric intakes during the 4 days of exercise at altitude were 1513 kcal (SED), 1787 kcal (EX), and 2325 kcal (EX + CHO). The EX + CHO group consumed an average of 404 g CHO/day compared to 187 and 159 g CHO/day for the EX and SED groups respectively. The EX + CHO group displayed a higher exercising respiratory exchange ratio (0.81 $\pm$ 0.01 vs 0.77 $\pm$ 0.01), lower blood and urine beta hydroxybutyric acid and averaged 12.5% greater voluntary miles run over the course of the 4 day study. The results of this study confirm and extend previous studies suggesting that carbohydrate supplementation is beneficial during strenuous exercise at high altitude.

INTRODUCTION

Anorexia and hypophagia frequently afflict soldiers participating in military operations requiring rapid ascent to high altitude, especially in the first few days of altitude exposure (15). High carbohydrate diets have been reported to lessen the symptoms and severity of acute mountain sickness and permit improved physical performance at altitude (8). Strenuous physical exertion coupled with reduced dietary carbohydrate intakes are known to act in concert to lower muscle glycogen levels at sea level (13, 27). Similar effects on muscle glycogen may occur at altitude (30). This suggests that carbohydrate supplementation prior to and during the initial exposure to altitude would be beneficial to physical performance by reducing anorexia, increasing carbohydrate and energy intakes and preventing decreases in muscle glycogen levels. Although high carbohydrate diets can enhance aerobic endurance exercise at sea level (13, 27), it is not established that high carbohydrate diets are as effective at high altitude. Consolazio et al (8) reported a beneficial effect of carbohydrate on work performance at 4300 meters elevation, but this was for exhaustive work of short (less than 10 min) duration.

We hypothesized that carbohydrate supplementation of the beverage component of a standard military field ration would increase voluntary ad libitum dietary carbohydrate intake and enhance endurance exercise performance in comparison to persons not provided carbohydrate supplementation during acute exposure to high altitude.

METHODS

Subjects. Twenty-nine male soldiers in good physical condition ranging in age from 18-34 yr volunteered to take part in this 6 day study of diet, exercise and altitude. All participants were briefed and signed volunteer consent agreements. This study was approved by the Tripler Army Medical Center Human

Use Committee and the Human Research Review Board of the Office of the Surgeon General. All subjects were occasional runners but none routinely ran more than 32 km/week. Subjects averaged (±SE) 75.5 ± 2.2 kg body weight, 18.0 ± 0.8% body fat and a VO_2 max of 52.6 ± 1.6 ml/min/kg at the beginning of the study.

Experimental Design. The subjects were divided into three groups consisting of two exercise and one sedentary group. The two exercise groups were matched according to their initial VO_2 max measurements. All three groups were provided unlimited amounts of a standard military field ration which they consumed ad libitum for 2 days at sea level and subsequently during a 4 day sojourn at high altitude (4100M). The control exercise group (EX) did not receive supplemental carbohydrate (CHO). The experimental exercise group (EX + CHO) received supplemental CHO. The sedentary control group (SED) did not receive supplemental CHO. The effects of exercise were evaluated by comparing EX to SED, and the effects of carbohydrate supplementation were evaluated by comparing EX + CHO to EX. The effects of altitude were evaluated within each experimental group by comparing that group's measurements at altitude with their sea level control measurements taken on day-1 prior to exposure to altitude. Subjects reported to Tripler Army Medical Center 2 days prior to traveling to altitude for sea level control measurements. They began eating the experimental rations at this time. Following 2 day. of baseline sea level measurements, subjects were transported from Oahu to Hilo, HI by airplane. They were then transported without delay by trucks from sea level at Hilo to the summit of Mauna Kea (4100 M elevation), Hawaii in an unstaged ascent lasting 90 min (day 0). The subjects bivouacked in tents and ran for 2 h each morning for 4 consecutive days (days +1,+2,+3,+4) between the hours of 0800 and 1000. Medical considerations necessitated the removal of 5 subjects from the study prior to completion. One subject was removed because of severe acute mountain sickness, one subject for

pulmonary edema, one subject for sleep apnea and low paO_2 and one subject for sore knees. These 4 subjects were from the EX + CHO group. The relationship of these casualties to carbohydrate and level of exercise is not clear and probably circumstantial. One subject's data was dropped from the EX group due to acute mountain sickness during the first two days at altitude. He did not run on day 1, but recovered enough to run on the remaining days of the experiment. His data was dropped because he did not complete the same workload as the rest of the subjects. The initial/final numbers for each group were EX 9/8; EX + CHO 10/6; and SED 10/10. Experiment comparisons will include only those subjects completing 4 days of running or sedentary activity at altitude.

Diets. All subjects consumed the standard military field ration, Meal, Ready-to-Eat (MRE III). This ration is packed pre-cooked in retortable foil pouches and can be consumed hot or cold. Facilities were available to heat ration components and hot water was available for coffee and hot chocolate mixes. The MRE ration consists of 1200 kcal/meal and is composed of (% of the kcal) 14% protein, 41% fat, and 45% carbohydrate. Subjects were permitted to consume as much of this ration as they desired. The supplements to the diets were as follows: The EX + CHO group could choose and consume ad libitum any combination of two sweetened beverages (Kool-Aid^R, General Foods Corp., White Plains, N.Y. and Carnation Hot Cocoa Mix, Carnation, Los Angeles, CA). Each beverage serving was further supplemented with 20 g of glucose polymers (Polycose^R, Ross Laboratories, Columbus, OH) to increase the carbohydrate density without significantly altering the taste or osmotic properties of the beverage. The Polycose^R supplemented Kool-Aid^R contained 144 kcal and 36 g CHO per serving. The Polycose^R supplemented hot cocoa contained 186 kcal and 42 g CHO per serving. The EX and SED groups could choose and consume ad libitum any combination of sugar-free beverages sweetened with aspartame (Sugar Free Kool-

Aid^R, General Foods Corp., White Plains, N.Y. and Carnaiton Sugar Free Hot Cocoa Mix, Carnation, Los Angeles, CA). The sugar free Kool-Aid^R contained 3 kcal per serving with essentially no carbohydrate. The sugar free hot cocoa mix contained 50 kcal per serving with 8 g CHO. All beverage supplements were served in unmarked containers and subjects did not know the identity or purpose of their beverage supplement until after the experiment was completed. Subjects were neither encouraged nor discouraged from consuming the beverage supplements. Other beverages available were water as well as coffee and hot chocolate mixes that were normal packaged components of the MRE ration. All three groups had equal access to these beverages. Food and beverage intakes were recorded daily on food record cards (Appendix 1). Food intakes were converted to nutrient intakes by applying a nutrient factor file for the MRE ration utilizing a data reduction program developed by the University of Hawaii and the Statistical Analysis System (SAS^R), SAS Jnstitute, Cary, NC 27511.

<u>Measurements</u>. Blood samples were drawn at sea level on day-1 at 0800 and again at 1000 to correspond to the times at which the pre and post-exercise blood samples were drawn at altitude on days +1 and +4. Twenty-four hour urine samples were collected daily. The following analyses were conducted on the blood samples: glucose, lactate, B-hydroxybutyrate, glycerol, cholesterol, high density lipoprotein cholesterol (HDL), and triglycerides. Glucose was analyzed by a commercial colorimetric method utilizing O-toluidine reagent (10). Lactate was analyzed by a commercial method oxidizing the lactate to pyruvate and measuring NADH formed at 340 nm (25). B-hydroxybutyrate was analyzed directly in serum and urine samples by measuring the NADH formed at 340 nm utilizing the enzyme B-hydroxybutyrate dehydrogenase with the reaction pulled by hydrazine (21). Glycerol was assayed on perchloric acid extracts of whole blood according to the modified enzymatic procedure of Spinella and Mager (28). Total blood

cholesterol was determined by a commercial enzymatic method (1). Cholesterol esters were hydrolyzed to free cholesterol and the free cholesterol was oxidized and the oxidation products subsequently measured colorimetrically. High density lipoprotein cholesterol was determined by a commercial method (2) utilizing dextran sulfate and Mg^{2+} to precipitate low and very low density lipoproteins and subsequently measuring HDL cholesterol left in solution. Triglycerides were analyzed by a commercial enzymatic method (3). The triglycerides were first hydrolyzed to free glycerol which was subsequently determined enzymatically by the disappearance of NADH at 340 nm. Twenty-four hour urine samples were collected from each man for each day. Urine samples were analyzed for B-hydroxybutyrate as described for blood. Urine samples from day -1, +1, and +4 were analyzed for total urinary nitrogen by a Kjeldahl procedure (4). Nitrogen balance was calculated similar to Wilmore (36) omitting fecal and sweat nitrogen which usually do not exceed 2g/man/day.

Maximal aerobic capacity (VO_2 max) of the members of the EX and the EX + CHO groups was measured at sea level 1 day before the altitude sojourn utilizing a graded treadmill exercise test (19). Expired gases were collected and monitored for O_2 consumption and CO_2 production utilizing the automated Sensor-Medics MMC Horizon system (22). The VO_2 max measurements were utilized to assign subjects to experimental groups to assure both groups were of similar aerobic capacity at the start of the experiment. The men were instructed to exercise at altitude at ~ 75% of their maximum heart rate (based upon the sea level VO_2 max test). Heart rates were monitorted at 1 km intervals during the exercise period. Six members of the EX and 5 members of the EX + CHO groups were tested to determine if diet had influenced their respiratory exchange ratio (RER) after 4 days of running at altitude. Subjects were permitted to run for approximately 1 h on their normal course and then transferred without delay to a treadmill set at 5.6

km/h, 0° grade. Gas exchange was measured continuously for 5 min or until a steady state RER was obtained while the subjects ran on the treadmill. After disconnecting from the respiratory apparatus, the subjects then resumed their normal course and completed their 2 h run.

Body fat estimations were calculated by the sum of 3 sites of skinfold caliper measurements according to the formula of Durnin and Womersley (12).

Exercise Regimen. Beginning at 0800 each morning at altitude subjects began running a cross country course along a 3 km length of unsurfaced roadway near the 4100 M bivouac site. Aid stations were established at the middle and both ends of the moderately hilly course to monitor heart rate and provide water to the subjects. Subjects were instructed to cover as many km as possible during the 2 h exercise period while maintaining their heart rates at approximately 75% of their sea level maximum. Walking alternated with running was permitted. Subjects covered 9 - 14 km/2 h, averaging 10 km/2 h for the 4 day period.

Environmental Conditions. The men were bivouacked in unheated tents. Temperatures ranged from -10 to 30°C. The volcanic terrain was devoid of vegetation, dry and dusty.

Statistical Analyses. The data were analyzed by a 2-way analysis of variance with repeated measures (29). Multiple mean comparisons were conducted posthoc by a Duncan's Multiple Range Test (37). Respiratory exchange ratios and nutrient intakes were compared by a non-paired t-test (29,34). Values shown in this paper represent the mean ± the standard error of the mean ($\bar{x}$ ± SE). Significant differences are reported at $P<0.05$. All mean values reported in this study (except where otherwise noted) were derived from the data for 8 (EX), 6 (EX + CHO) and 10 (SED) individuals.

RESULTS

The two exercising groups were initially paired to be similar in age, body weight, percent body fat, aerobic capacity (VO_2 max) and predicted running endurance. These initial descriptive group characteristic values are shown in Table 1, along with the same descriptive characteristics when five subjects were removed from the data for medical reasons, as discussed in the methods section. Although partial data was collected on these five volunteers, it was not included because they failed to complete a full 4 days of exercise at altitude. Four of the five casualties came from the EX + CHO group. The VO_2 max of these four casualties was 54.2 $\pm$ 5.3 ml/min/kg compared to a VO_2 max of 49.5 $\pm$ 2.8 for the remaining six members of their group. There was no common symptom among the predominant symptomatology causing the individuals to be removed from the study (pulmonary edema, sleep apnea and low paO_2, headache and nausea, and sore knees). The net effect of the removing these individuals from the study left a heavier and less aerobically fit (lower VO_2 max) group to represent the EX + CHO group. Despite this presumed handicap, the EX + CHO group recorded 12.5% more voluntary km ran/walked during the 4 days at altitude, compared to the EX group. A comparison km run per day is shown in Fig. 1. The carbohydrate supplemented group completed significantly more km ($P<0.05$) on days 2 and 3. 2. The differences recorded for days 1 and 4 were not significantly different; however, the EX + CHO group averaged signficantly ($P<0.05$) more km/man/day over the 4 day exercise period (12.04 $\pm$ 0.33 vs 10.69 $\pm$ 0.16, EX + CHO vs EX).

Mean daily caloric intakes and carbohydrate intakes for sea level, the day of travel from sea level to altitude (transition day) and the next 4 days at altitude are shown in Figs. 2 and 3. Daily group mean nutrient intakes for energy, fat, carbohydrate, protein, vitamins and minerals are shown in appendix 2. Caloric intakes for the three groups ranged from 2550 - 3025 kcal/man/day

while resting at sea level immediately prior to going to altitude. The EX + CHO group did not consume the carbohydrate supplemented hot chocolate during the two days at sea level because of the high (32°C) ambient temperature, but they did consume the carbohydrate supplemented Kool-Aid[R] beverage. The mean carbohydrate intake at sea level on the day prior to traveling to altitude was 324 g/man/day for the EX group compared to 378 g/man/day for the EX + CHO group. Transition to altitude was accompanied by an immediate decrease in caloric consumption resulting in a concomitant decrease in carbohydrate intake in the two groups not receiving the carbohydrate supplement. Conversely, the carbohydrate intake of the EX + CHO group remained similar to their sea level values due to their consumption of the CHO supplemented beverages. No exercise other than routine camp chores was done on the transition day. The camp had been established and tents had been erected previously by soldiers who were not test subjects. On the day after the ascent the two exercise groups began running and the sedentary group was engaged in a series of psychological tests. (The results of the psychological testing will be reported elsewhere.) Caloric and carbohydrate intakes fell off markedly in the EX and SED groups. The SED group's food intake remained low throughout the next 4 days at altitude. The EX group displayed a trend toward increasing food intakes after the first day at altitude, however this group was still in approximately 1000 kcal/man/day negative energy balance by day +4. The EX + CHO group maintained a relatively uniform energy intake of approximately 2300 kcal/man/day after day +1. Carbohydrate intakes for the carbohydrate supplemented group remained slightly higher than their sea level intakes and significantly higher ($P<0.05$) than those of the EX group whose carbohydrate intakes at altitude were markedly lower than their sea level intakes. Nutrient intakes for kcal, carbohydrate, fat and protein for the 2 days at sea level compared to the 4 days at altitude are shown in Table 2.

There were no significant differences in carbohydrate intakes at sea level. At 4100 M the carbohydrate supplemented group consumed significantly more ($P<0.05$) carbohydrate than the non-supplemented exercise group. During the 4 days at altitude, the carbohydrate supplement provided approximately 70% of the carbohydrate and 50% of the energy (kcal) consumed by the EX + CHO group (Table 3). The frequency of beverage consumption and daily carbohydrate and energy intakes for the EX + CHO group by source (Hot chocolate, Kool-Aid^R, Other Food Sources) is shown in Appendix 3.

Although all three groups had ad libitum access to the supplemental Kool-Aid^R and hot chocolate beverages, the group receiving the carbohydrate supplemented beverages consumed a slightly greater number of supplemented beverages than the groups receiving the aspartame-sweetened beverages. This may have been due to taste perception differences between the beverages since all three groups consumed similar quantities of the MRE cocoa beverage powder (Appendix 3). These results indicate that Kool-Aid^R was a better candidate for carbohydrate supplementation under moderate climatic conditions at altitude than hot chocolate. Colder conditions might alter this relationship; however, under the conditions of this study, the subjects consumed the Kool-Aid^R primarily to satisfy thirst, and had less need of a warming beverage.

By day +4 at altitude the EX group had lost 2.1 ± 0.7 kg of body weight compared to 1.4 ± 0.3 kg for the EX + CHO group. This difference was not significantly different, $P > 0.05$.

Fluid intakes, 24 h urine volumes, and total osmoles of solute excreted are shown in Table 4. Total fluid intakes were higher for the exercising groups than the SED group and were similar for the two exercise groups. Urine volume was significantly lower for the EX + CHO group due to the lower solute load associated with a reduced ingestion of osmotically active nutrients such as

protein and sodium. Daily protein intakes were 71 $\pm$ 14 and 57 $\pm$ 7 g for the EX and the EX + CHO groups, respectively. Sodium intakes were 3910 $\pm$ 553 and 3062 $\pm$ 457 mg for these same groups. Apparently the quantity of carbohydrate consumed by the EX + CHO group blunted their intake of the basal ration resulting in slightly reduced protein and sodium intakes. Although these differences were not significantly different, $P>0.05$, the net effect of the CHO supplement was a trend toward reduced urinary solute load and, as a consequence, a reduced volume of urine excreted. These relationships are illusrated in Figures 4 and 5.

Urinary nitrogen excretion was measured on the day immediately prior to going to altitude (Day-1), during the first full day at altitude (Day+1) and on the fourth day at altitude (Day+4). Fecal and sweat nitrogen were not measured but were probably similar between groups and relatively minor compared to urine nitrogen. A modified nitrogen balance was calculated utilizing food source nitrogen (protein ÷ 6.25 g protein/g nitrogen) and urinary Kjeldahl nitrogen determinations. Nitrogen intakes and urinary nitrogen excretion are shown in Table 5. The net nitrogen balance is shown in Figure 6. All three groups were in positive balance at sea level. Both the EX and SED groups were in negative balance on Day+1 at altitude. Nitrogen intakes were similar (but lower than sea level) on this day for all three groups. The EX + CHO group remained in positive nitrogen balance, in contrast to the non-supplemented groups. This was due to a reduced nitrogen excretion by the EX + CHO group. By day+4 at altitude, all three groups were close to nitrogen balance with no significant differences between groups. Urinary creatinine excretion averaged 2100 mg creatinine/day and was not significantly altered by altitude or diet.

B-hydroxybutyrate was measured in urine and serum as an index of ketosis. Urine B-hydroxybutyrate in 24 h urine samples is shown in Table 6. In general,

the incidence of ketosis was markedly less in the EX + CHO group. On day +2, at altitude, 2 out of 8 were negative for urine ketones in the EX group, 6 out of 6 were negative in the EX + CHO group and 5 out of 10 were negative in the SED group. Serum B-hydroxybutyrate levels were generally lower in the EX + CHO group at altitude compared to the EX group, both pre and post exercise (Fig. 7). Serum glycerol was increased at altitude in resting blood samples and post exercise (Fig. 8). The post exercise increase in serum glycerol was, although not significantly different, somewhat less in the EX + CHO group suggesting a difference in lipolysis and probably free fatty acid oxidation between the two groups. Further evidence of a difference in carbohydrate and lipid utilization between the EX and the EX + CHO groups was indicated by the latter's significantly higher ($P<0.05$) post-exercise serum lactate levels on Day+1 at altitude (Fig. 9). This difference in substrate utilization for energy during exercise implied by the blood metabolite data of Figs. 7-9 was confirmed by measuring the RER of 6 subjects from the EX and 5 subjects from the EX + CHO groups after 1 h of running at altitude. The RER for the EX group was 0.77 ± 0.01 and 0.81 ± 0.01 for the EX + CHO group. The RER for the EX + CHO group was significantly greater ($P<0.05$) than the EX group, indicating a greater reliance on carbohydrate for energy in the carbohydrate supplemented group. Blood glucose was similar between all three groups although the sedentary tended to display slightly lower values on days 3 and 4 at altitude (Table 7).

Serum triglyceride and cholesterol were lowered during altitude exposure, probably due to a combination of reduced food intake and exercise (Table 8). Serum triglycerides and cholesterol were higher initially at sea level in the EX + CHO group compared to the other two groups. This was not related to the conditions of this study and was probably related to other influences prior to the start of this experiment. The percentage decrease in triglycerides and

cholesterol from Day-1 to Day+4 was relatively similar for both exercise groups. High density lipoprotein cholesterol was similar in all three groups at sea level. By Day+4 at altitude, HDL in the EX group showed no change. There was a small but non-significant decrease in the EX + CHO group. The SED group displayed a significant ($P<0.05$) decrease in HDL over the same time period.

DISCUSSION

Acute high altitude exposure (greater than 3500 M) results in reduced food intake due to hypophagia exacerbated by headaches, nausea and vomiting (14). Both the elevation and duration of exposure influence the severity of these symptoms of acute mountain sickness (6). At a given elevation, the severity of acute mountain sickness usually increases over the first 48 to 72 hours and then decreases. Food consumption inversely parallels these symptoms. Near normal food intakes at altitude may be achieved with time (several days to several weeks) (14). Carbohydrate craving has been anecdotally reported by travelers and expeditioners at altitude (24), but this has not been established experimentally (26). Some investigators have reported physiologic benefits of increased carbohydrate ingestion at altitude (8,11,16). Theoretically, feeding high carbohydrate diets during altitude exposure should give the best energy yield/liter of oxygen consumed since carbohydrate is more highly oxidized than either protein or fat. Energy yields per liter of oxygen are 3.7 to 12.7% greater for carbohydrate than protein or fat (20). Hansen et al (16) have reported increased blood oxygen tension when high carbohydrate diets were fed at altitude. Dramise et al (11) found an increase in pulmonary diffusion capacity following the consumption of high carbohydrate diets at altitude. Consolazio et al (8) reported that feeding high carbohydrate diets at high altitude resulted in a reduced severity of symptoms of acute mountain sickness and increased work

capacity in relatively short term high exertion work (walking at 8% grade carrying 20 kg packs).

The results of the present study lend further support to previous studies ascribing physiological advantages to diets high in carbohydrate. This study was designed to increase voluntary energy intake during acute high altitude exposure by providing supplemental carbohydrate via the beverage component of the diet. In this manner, the problem of hypophagia could be circumvented and the relative contribution of carbohydrates to the total energy intake could be increased. The metabolic demands upon liver and muscle glycogen were probably increased by accompanying altitude exposure with strenuous aerobic work (30). The combination of a negative energy balance and reduced carbohydrate intake due to anorexia and the repetitive daily demand upon muscle and liver glycogen stores associated with 2 h/day of strenuous exercise in all likelihood resulted in reduced muscle glycogen repletion. Carbohydrate intakes of 187 g/day recorded for the EX group would not be adequate to replenish muscle glycogen levels under sea level conditions, whereas the carbohydrate intakes recorded for the EX + CHO group of 404 g/day should result in adequate repletion (27).

Increased FFA, glycerol and catecholamines and decreased insulin levels in individuals exposed to altitude have been reported, suggesting that fat may be the principal fuel for exercise at altitude (5,17,31,35,38). We found a significant increase in glycerol in the blood of the non-carbohydrate supplemented group on the first day of altitude exposure, but not in the carbohydrate supplemented group. The energy intakes of these two groups were 2300 and 3000 kcal respectively for the day of transition to altitude prior to the morning of blood sampling. This suggests that elevated glycerol (FFA) upon acute altitude exposure is probably related to inadequate energy intake and resultant mobilization of body fat. The provision of supplemental kcal in the

form of carbohydrate also resulted in higher blood lactate and lower serum post-exercise glycerol and B-hydroxybutyrate levels. These results are consistent with an increased oxidation of carbohydrate during exercise in the EX + CHO group. This was an anticipated metabolic response to altering the amount and proportion of carbohydrate in the diet and was confirmed by a significantly higher RER during exercise in the EX + CHO group compared to the EX group. Assuming that protein was not a major substrate for energy production during this exercise, the observed RER's of 0.77 and 0.81 for the EX and EX + CHO groups, respectively, permit an estimation that approximately 23 and 37% of the kcal expended during exercise were provided by carbohydrate (20).

The reduction in blood triglycerides and cholesterol observed for the two exercising groups is consistent with previous reports on the effect of reduced dietary energy intake and vigorous exercise on blood lipids (18,32). The sedentary group, which also consumed reduced energy intakes but did not exercise, displayed a similar but smaller decrease in triglycerides and cholesterol. The sedentary group also displayed a significant 16 1/2% decrease in HDL cholesterol (HDL-C). It is possible that this decrease in HDL-C was related to the lack of exercise in this group. Increases in HDL-C are observed in individuals that have been engaged in a long term aerobic training program and tend to decrease following the cessation of training (32). However, changes in HDL-C during detraining are usually modest over relatively short time periods (32). The possibility exists that anorexia (caloric restriction), inactivity and altitude (hypoxia) may interact to exert a synergistic effect upon the reduction of HDL-C. The carbohydrate supplemented exercise group displayed a 8.7% decrease in HDL-C over the same time period despite the fact that they were exercising daily. This decrease was not significantly different from their sea level control value but was significantly different from the non-carbohydrate

supplemented exercise group on day 4 at altitude. Thompson et al (33), have reported that HDL-C levels of endurance athletes are sensitive to changes in dietary fat and carbohydrate. They found that high carbohydrate diets produced a prompt and significant decrease in HDL-C in athletes consuming calorie adequate diets at sea level (33). The trend toward lower HDL-C in the carbohydrate supplemented group in our study is in general agreement with Thompson et al (33) albeit under somewhat different dietary, environmental and workload conditions.

Negative nitrogen balances have been reported during acute altitude exposure (7). This is primarily due to inadequate energy intake rather than hypoxia per se (9). Nitrogen balance was negative for both the EX and SED groups for the first day at altitude. The EX + CHO group remained in positive nitrogen balance on this day primarily because of a significantly reduced nitrogen excretion. Nitrogen intakes were similar in all three groups. The EX + CHO group consumed approximately 900 kcal/day more energy than the EX group on that day. This apparently resulted in sparing of dietary protein from oxidation to provide energy as evidenced by the reduced nitrogen excretion in the urine. By the 4th day, food intake had increased significantly in the EX group and nitrogen balance had been restored. Recovery of appetite and the abatement of acute mountain sickness after 4 days at altitude is consistent with the etiology of acute mountain sickness.

The total osmotic load and resultant water requirement were greater in the non-carbohydrate supplemented groups. Both the EX and SED groups consumed greater amounts of protein and sodium than the EX + CHO group, but less total kcal. Consumption of the beverage carbohydrate supplement by the EX + CHO group reduced the intake of the protein and sodium portion of the basal diet approximately 20% while increasing the net kcal intake by 30%.

The total distance run was 12.5% greater over the course of the 4 days of running for the group given the carbohydrate supplements. The greatest difference was on day +2 of running when the EX + CHO group covered an average of 13.4 km/man/2h compared to 10.6 km/man/2h for the EX group. Although the two groups were initially matched for VO_2 max, weight, and age, a proportionately larger number of runners had to be removed from the EX + CHO group prior to the completion of the 4 days of exercise due to injuries. This resulted in a heavier, older, and less aerobically fit group of 6 individuals remaining in the EX + CHO group. Despite this apparent disadvantage, the EX + CHO group consistently covered more distance/day than the EX group.

CONCLUSIONS

The results of this study demonstrated that supplementing the diet of soldiers exercising at 4100 M elevation with 250-350 g of carbohydrate per day through the beverage component of the diet improved the energy balance and decreased ketonemia, nitrogen excretion, urinary osmotic load and water requirements. In addition to altering the physiologic status of men exercising at high altitude, provision of extra energy in the form of carbohydrate may lessen decrements in aerobic performance associated with hypophagia and glycogen depletion at altitude.

RECOMMENDATIONS

1. That a halogen compatible flavored beverage base powder containing 35-40 g carbohydrate/beverage packet be provided as a ration supplement for military high altitude operations. These beverage powders should be provided ad libitum. For planning purposes, 5-7 beverage packets/man/day should be adequate.

2. That a hot chocolate beverage base powder containing 35-40 g carbohydrate/beverage packet be provided as a ration supplement for cold weather military high altitude operations. These should be provided ad libitum as an alternate beverage carbohydrate source. For planning purposes 2-4 hot chocolate beverage packets/man/day should be adequate, assuming the flavored beverage base powder described in (1) above is also available.

3. It is essential that adequate water be provided to permit the utilization of these beverage base powder carbohydrate supplements. A minimum of three L/man/day can be assumed for planning purposes.

4. When operationally feasible, these beverage supplements should be provided 1-2 days in advance of travel to high altitude and for at least the first 4 days of high altitude operations.

TABLES

TABLE 1. Anthropometric description of test subjects before and after omitting those subjects removed for medical reasons

Group	N	Age* (yr)	Body Weight (kg)	% Body Fat (%)	VO_2 Max (ml/min/kg)
(Initial Grouping)					
Exercise	9	21.3 ± 0.7	72.5 ± 3.3	16.4 ± 1.2	52.8 ± 2.1
Exercise + CHO	10	22.3 ± 1.4	73.5 ± 4.0	18.7 ± 1.3	51.4 ± 2.6
Sedentary	10		77.6 ± 3.1	17.2 ± 1.2	
(Final Grouping)					
Exercise	8	21.3 ± 0.8	71.5 ± 3.6	16.5 ± 1.3	54.5 ± 1.4
Exercise + CHO	6	23.2 ± 2.2	77.3 ± 4.0	20.3 ± 1.1	49.5 ± 2.8
Sedentary	10		77.6 ± 3.1	17.2 ± 1.2	

Values shown are $\bar{x}$ ± SE. Refer to Methods section for a description of reasons for removing test subjects from the final grouping.

* The ages for the sedentary group were similar to the exercise groups but were not recorded.

TABLE 2. Mean daily nutrient intakes at sea level and 4100 meters elevation

Group	N	Energy (kcal)	Protein (g)	Fat (g)	Carbohydrate (g)
(Sea Level)					
Exercise	8	2881 ± 347	124 ± 16	128 ± 13	307 ± 131
Exercise + CHO	6	2300 ± 147	80 ± 6*	81 ± 8*	312 ± 26
Sedentary	10	2349 ± 142	97 ± 7	111 ± 9	238 ± 20
(4100 Meters)					
Exercise	8	1787 ± 288	71 ± 14	82 ± 16	187 ± 27
Exercise + CHO	6	2325 ± 215	57 ± 7	54 ± 6	404 ± 46*
Sedentary	10	1513 ± 280	64 ± 11	67 ± 14	159 ± 31

Values shown are $\bar{x} \pm$ SE. Sea Level means are from two consecutive days immediately prior to going to altitude. 4100 meter means are from four consecutive days at altitude.

* Comparisons of Exercise + CHO vs Exercise and comparisons of Sedentary vs Exercise are significantly different, $P<0.05$.

TABLE 3. Source of carbohydrate intakes of carbohydrate supplemented group at sea level and at 4100 meters altitude

Carbohydrate Source	Sea Level	Transition	Altitude			
	Day - 1	Day 0	Day +1	Day +2	Day +3	Day +4
		(g CHO/man/day)				
Ration Food	240	209	73	123	134	134
Hot Chocolate + Polycose[R]	0	168	161	28	56	49
Kool Aid[R] + Polycose[R]	138	138	186	246	222	204
Total, all sources	378	515	420	397	412	387

TABLE 4. Fluid intakes, urine volumes and urine solute excretion during four days at 4100 meters elevation

Group	N	Fluid Intake (ml/man/24h)	Food Source Water (ml/man/24h)	Urine Volume (ml/man/24h)	Urinary Osmols (mOsmol/man/24h)
Exercise	8	2406 $\pm$ 87	162 $\pm$ 34	1113 $\pm$ 76	691 $\pm$ 48
Exercise + CHO	5	2440 $\pm$ 77	165 $\pm$ 21	675 $\pm$ 45*	507 $\pm$ 41
Sedentary	10	1412 $\pm$ 88*	227 $\pm$ 43	1008 $\pm$ 73	760 $\pm$ 31

Values shown represent the $\bar{x} \pm$ SE for 4 days. A complete 24h urine collection was not available for 1 of the 6 men in the Exercise + CHO group.

Fluid intakes include water and beverages, but not food source water.

* Comparisons for Exercise vs Exercise + CHO and Exercise vs Sedentary significant, $P<0.05$.

TABLE 5. Nitrogen balance at sea level and at 4100 meters altitude

Group	Nitrogen Intake	Nitrogen Excretion	Nitrogen Balance
	(g/man/day)		
Day -1 (sea level)			
Exercise	21.39 ± 2.63	12.74 ± 1.49	+8.64 ± 1.61
Exercise + CHO	15.42 ± 0.97*	10.34 ± 1.22	+5.09 ± 1.14
Sedentary	15.64 ± 1.49*	13.27 ± 1.05	+2.36 ± 1.31*
Day +1 (4100 M)			
Exercise	8.11 ± 3.08	13.34 ± 1.45	-5.23 ± 2.51
Exercise + CHO	9.39 ± 0.97	8.03 ± 1.85*	+1.37 ± 1.66*
Sedentary	10.99 ± 1.88	13.20 ± 0.84	-2.21 ± 1.44
Day +4 (4100 M)			
Exercise	13.05 ± 2.63	11.40 ± 1.26	+1.65 ± 1.54
Exercise + CHO	8.73 ± 1.68	8.96 ± 1.02	-0.23 ± 1.46
Sedentary	11.67 ± 2.49	13.38 ± 1.10	-1.71 ± 1.81

For purposes of this table nitrogen balance = nitrogen intake - urinary nitrogen excretion. Fecal and sweat nitrogen were <u>not</u> measured but usually do not exceed 1-2 g/man/day (36). Values shown are x ± SE.

* Comparisons for Exercise vs Exercise + CHO and Exercise vs Sedentary significantly different, P<0.05.

TABLE 6. Urine B-hydroxybutyrate excretion at sea level and at 4100 meters altitude

Group	Sea Level	Altitude			
	Day - 1	Day +1	Day +2	Day +3	Day +4
		(mmol/man/day)			
Exercise	0	1.46 ± 0.75	1.68 ± 0.84	1.23 ± 0.67	0.97 ± 0.51
Exercise + CHO	0	0^{*}	0^{*}	0.17 ± 0.17	0.43 ± 0.28
Sedentary	0	0.15 ± 0.10	0.56 ± 0.27	1.96 ± 1.30	1.02 ± 0.52

Values shown are $\bar{x} \pm$ SE.

* Exercise + CHO values on Days +1 and +2 are significantly different, $P<0.05$ compared to the Exercise group values.

TABLE 7. Serum glucose pre and post exercise or rest at sea level and 4100 meters elevation

Group		Sea Level	Altitude	
		DAY - 1	DAY + 1	DAY + 4
Exercise	Pre	74.9 ± 3.1	82.9 ± 4.1	74.8 ± 2.0
	Post	83.6 ± 2.1[1]	70.8 ± 3.5[1]	78.5 ± 2.4
Exercise + CHO	Pre	72.3 ± 2.8	80.0 ± 2.1	70.7 ± 3.0
	Post	81.7 ± 1.6[1]	76.0 ± 4.3	76.7 ± 3.2
Sedentary	Pre	76.5 ± 2.0	74.3 ± 3.8[2]	68.8 ± 2.8
	Post	87.3 ± 1.6[1]	74.4 ± 3.5	68.2 ± 1.8[3]

[1] Significantly different Pre vs Post within treatment group

[2] Significantly different Sedentary vs Exercise, Pre vs Pre

[3] Significantly different Sedentary vs Exercise, post vs Post

TABLE 8. Serum Triglyceride, Cholesterol and High Density Lipoprotein Cholesterol at sea level and 4100 meters altitude

Group	Sea Level Day -1	Altitude Day +1	Altitude Day +4
		(mg/dl)	
<u>TRIGLYCERIDE</u>			
Exercise	75.1 ± 6.0	68.0 ± 6.4	$51.6 \pm 3.0^{+}$
Exercise + CHO	$131.0 \pm 21.0^{*}$	$102.3 \pm 13.6^{*,+}$	$83.0 \pm 11.2^{*,+,++}$
Sedentary	75.7 ± 5.0	$58.5 \pm 2.9^{+}$	63.9 ± 3.6
<u>CHOLESTEROL</u>			
Exercise	158.3 ± 7.1	$163.3 \pm 8.9^{++}$	$143.9 \pm 6.2^{+}$
Exercise + CHO	$172.7 \pm 7.3^{*}$	$173.2 \pm 7.7^{++}$	$147.3 \pm 6.4^{+}$
Sedentary	$178.0 \pm 9.0^{*}$	$174.0 \pm 8.8^{++}$	$158.5 \pm 8.4^{*,+}$
<u>HIGH DENSITY LIPOPROTEIN CHOLESTEROL</u>			
Exercise	37.4 ± 2.5	38.3 ± 2.8	37.4 ± 2.4
Exercise + CHO	36.5 ± 3.2	34.8 ± 2.2	$33.3 \pm 2.1^{*}$
Sedentary	40.5 ± 2.1	40.1 ± 2.0	$33.8 \pm 2.5^{*,+,++}$

Blood samples were taken at rest following an overnight fast. Values are $\bar{x} \pm$ SE.

* Values in the same day with this superscript are significantly different $P<0.05$, for the comparisons EX vs SED or EX + CHO vs EX.

\+ Values in the same treatment group with this superscript are significantly different, $P<0.05$, for altitude vs sea level comparisons.

++ Values in the same treatment group with this superscript are significantly different, $P<0.05$, for altitude day +1 vs altitude day +4.

FIGURES

FIGURE LEGENDS

Figure 1. Effect of carbohydrate supplement on voluntary distance run per day at 4100 meters altitude. Values shown represent the mean distance ran/walked $\pm$ SE (km/2h/man/day). The differences on days 2 and 3 were significantly different, $P<0.05$.

Figure 2. Mean daily intakes for calories during the day at sea level immediately prior to traveling to altitude, during the day of transition to altitude and for 4 days of exercise at 4100 meters altitude. The recommended level of 3200 kcal/man/day is that recommended for soldiers engaged in moderate to heavy physical activity (23).

Figure 3. Mean daily intakes for carbohydrate during the day at sea level immediately prior to traveling to altitude, during the day of transition to altitude and for 4 days of exercise at 4100 meters altitude. The recommended level of 440 g/man/day is the amount of carbohydrate recommended for operational military rations utilized by soldiers engaged in moderate to heavy physical activity (23).

Figure 4. Effect of sodium and protein intakes on urinary solute excretion during rest or exercise at 4100 M altitude. Values shown are the mean 24 h urine solute excretions for 4 days at altitude. Mean daily sodium and protein intakes during this time period are shown above each bar.

Figure 5. Effect of exercise and carbohydrate supplementation on fluid intakes and urine volumes at 4100 M altitude. Values shown are 24 h means for 4 days at altitude. EX + CHO urine volume was significantly different, $P<0.05$, compared to EX, SED fluid intake was significantly different from EX, $P<0.05$.

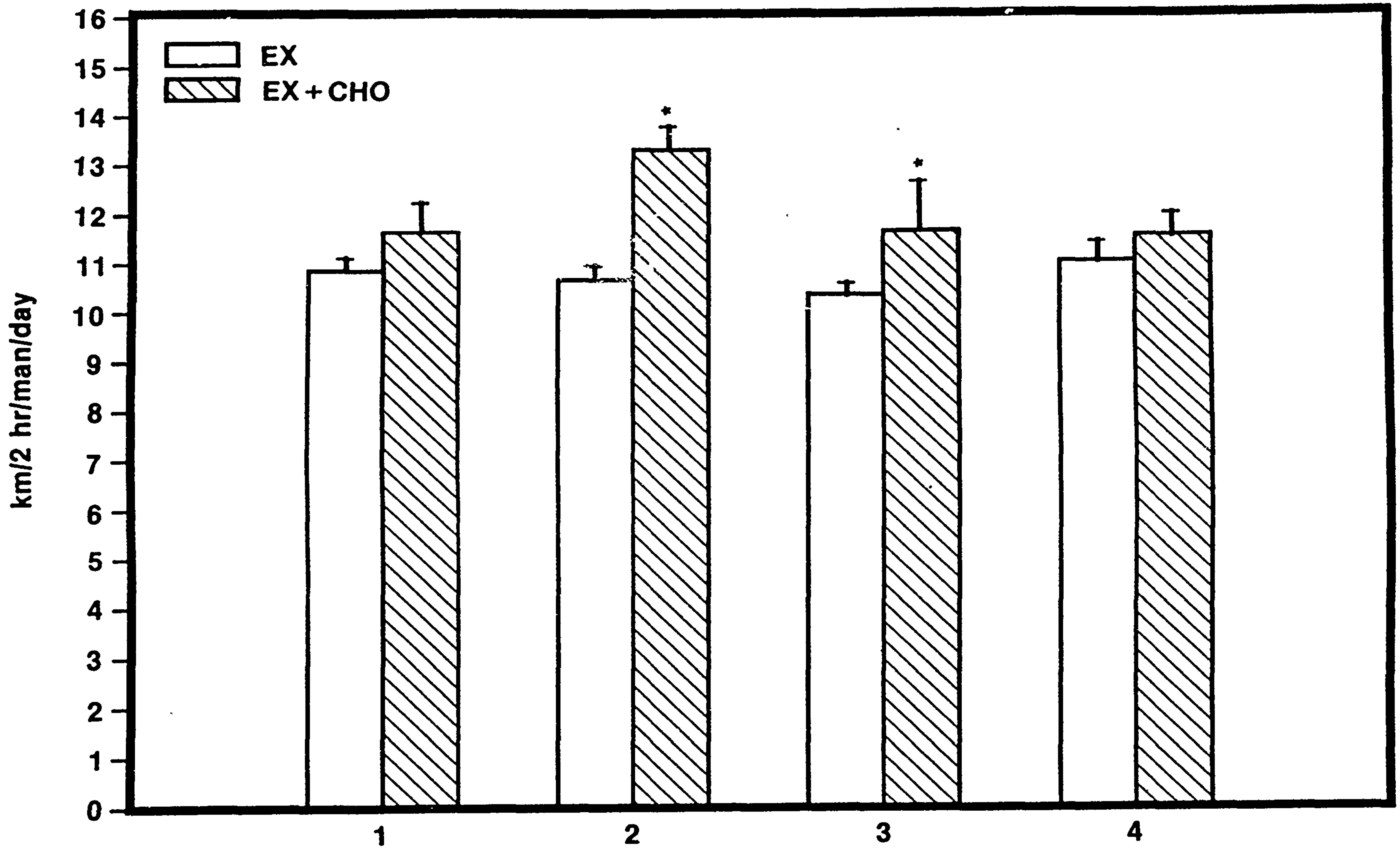
Figure 6. Effect of exercise and carbohydrate supplement on nitrogen balance at sea level, day +1 and day +4 at altitude. Refer to table 5 for nitrogen intakes and excretion values. On day +1, EX + CHO was significantly different from EX, $P<0.05$.

Figure 7. Serum B-hydroxybutyrate in pre and post exercise blood samples at sea level and 4100 meters altitude. Day -1 blood samples at sea level were both taken at rest, 2h apart. Post exercise blood samples were taken immediately following 2h of exercise at altitude.

Figure 8. Serum glycerol in pre and post exercise blood samples at sea level and 4100 meters altitude. Day -1 blood samples at sea level were both taken at rest, 2h apart. Post exercise blood samples were taken immediately following 2h of exercise at altitude.

Figure 9. Serum lactate in pre and post exercise blood samples at sea level and 4100 meters altitude. Day -1 blood samples at sea level were both taken at rest, 2h apart. Post exercise blood samples were taken immediatley following 2h of exercise at altitude.

EFFECT OF CARBOHYDRATE SUPPLEMENT ON VOLUNTARY KILOMETERS RUN AT 4100 M ALTITUDE



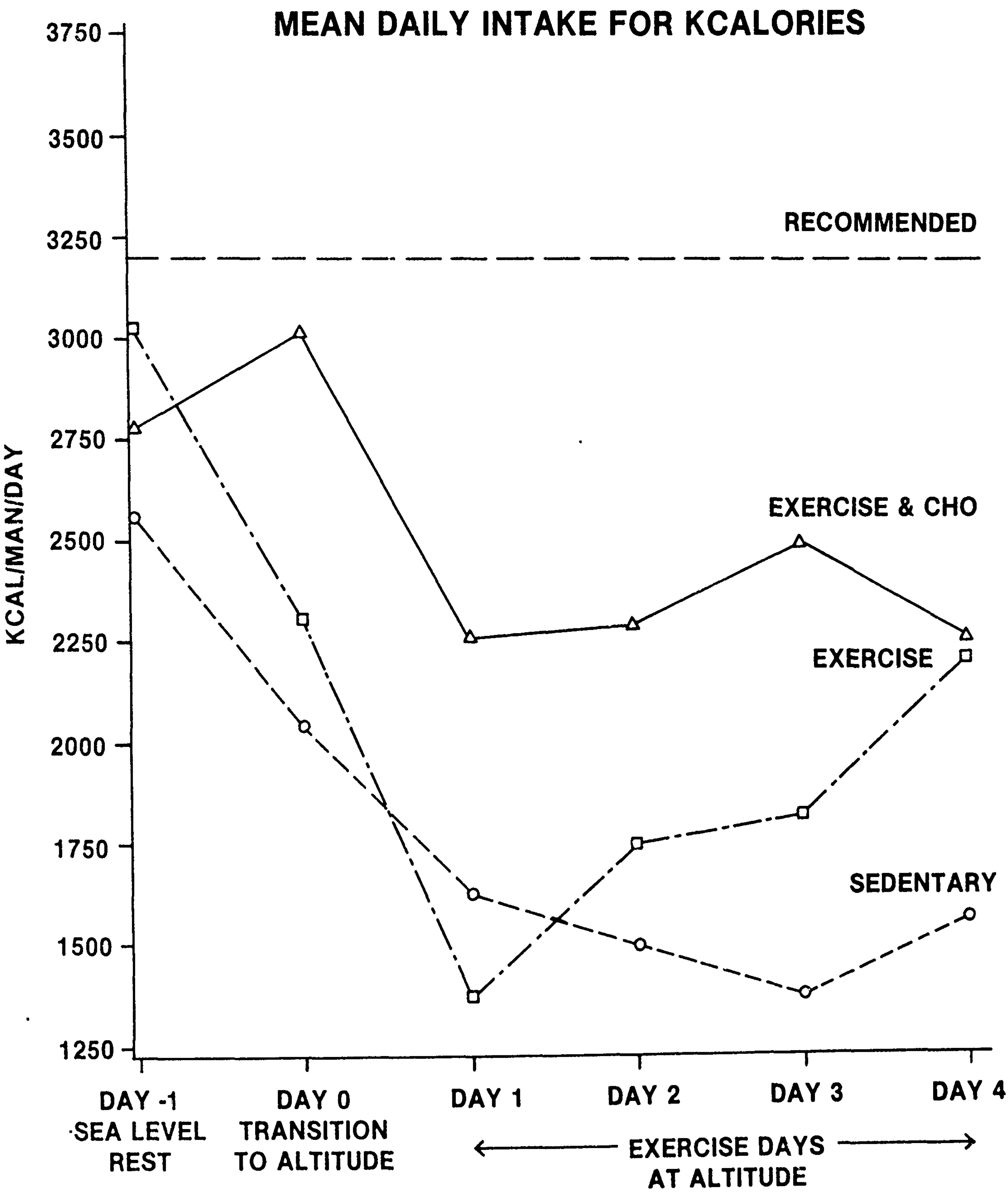

MEAN DAILY INTAKE FOR KCALORIES
3750
3500
3250
3000
2750
2500
2250
2000
1750
1500
1250
KCAL/MAN/DAY
RECOMMENDED
EXERCISE & CHO
EXERCISE
SEDENTARY
DAY -1
SEA LEVEL
REST
DAY 0
TRANSITION
TO ALTITUDE
DAY 1
DAY 2
DAY 3
DAY 4
EXERCISE DAYS
AT ALTITUDE

FIGURE 2

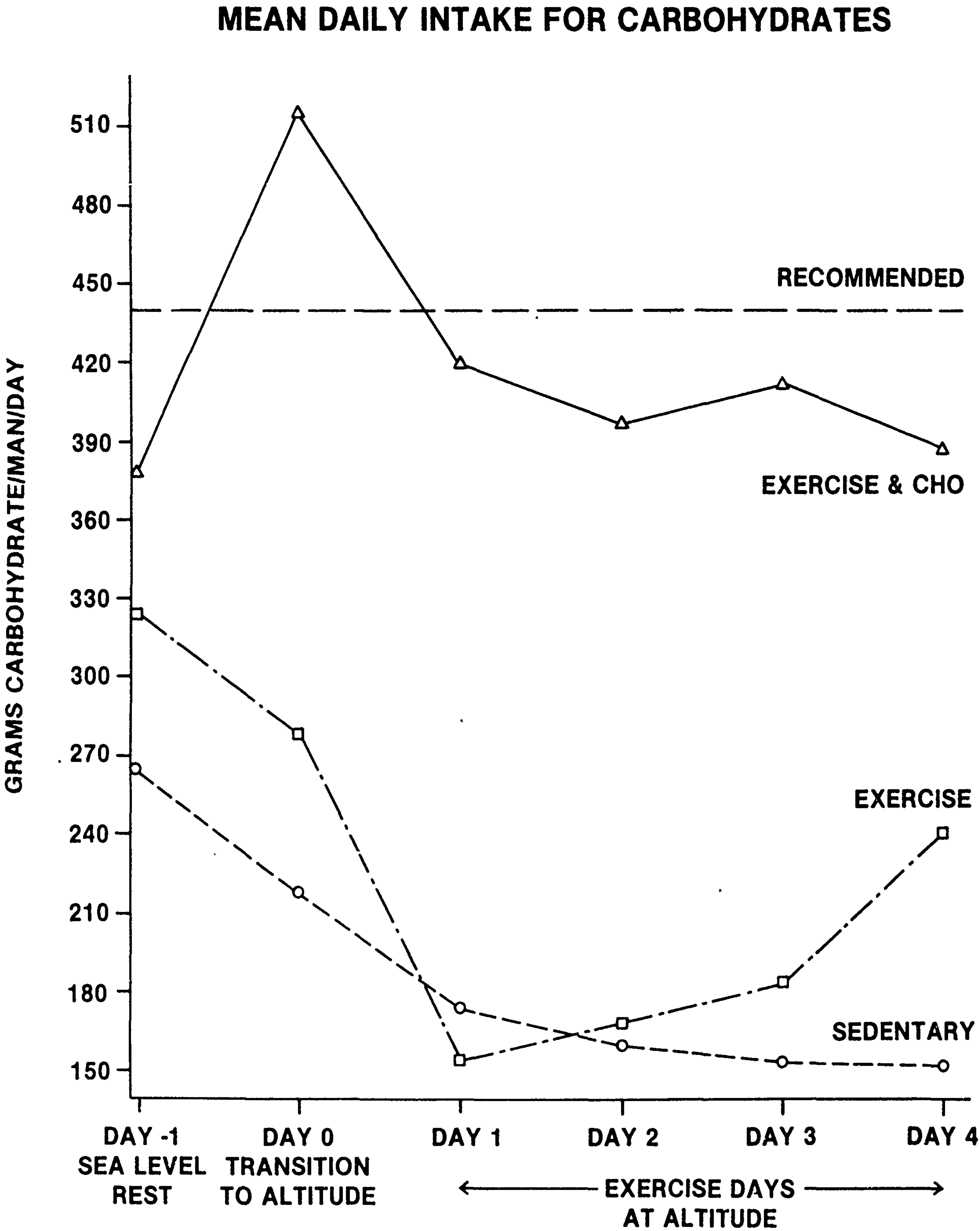

MEAN DAILY INTAKE FOR CARBOHYDRATES
GRAMS CARBOHYDRATE/MAN/DAY
510
480
450
420
390
360
330
300
270
240
210
180
150
RECOMMENDED
EXERCISE & CHO
EXERCISE
SEDENTARY
DAY -1
SEA LEVEL
REST
DAY 0
TRANSITION
TO ALTITUDE
DAY 1
DAY 2
DAY 3
DAY 4
EXERCISE DAYS
AT ALTITUDE

FIGURE 3

Effect of Sodium and Protein Intakes on Urinary Solute Excretion During Rest or Exercise at 4100 M Altitude

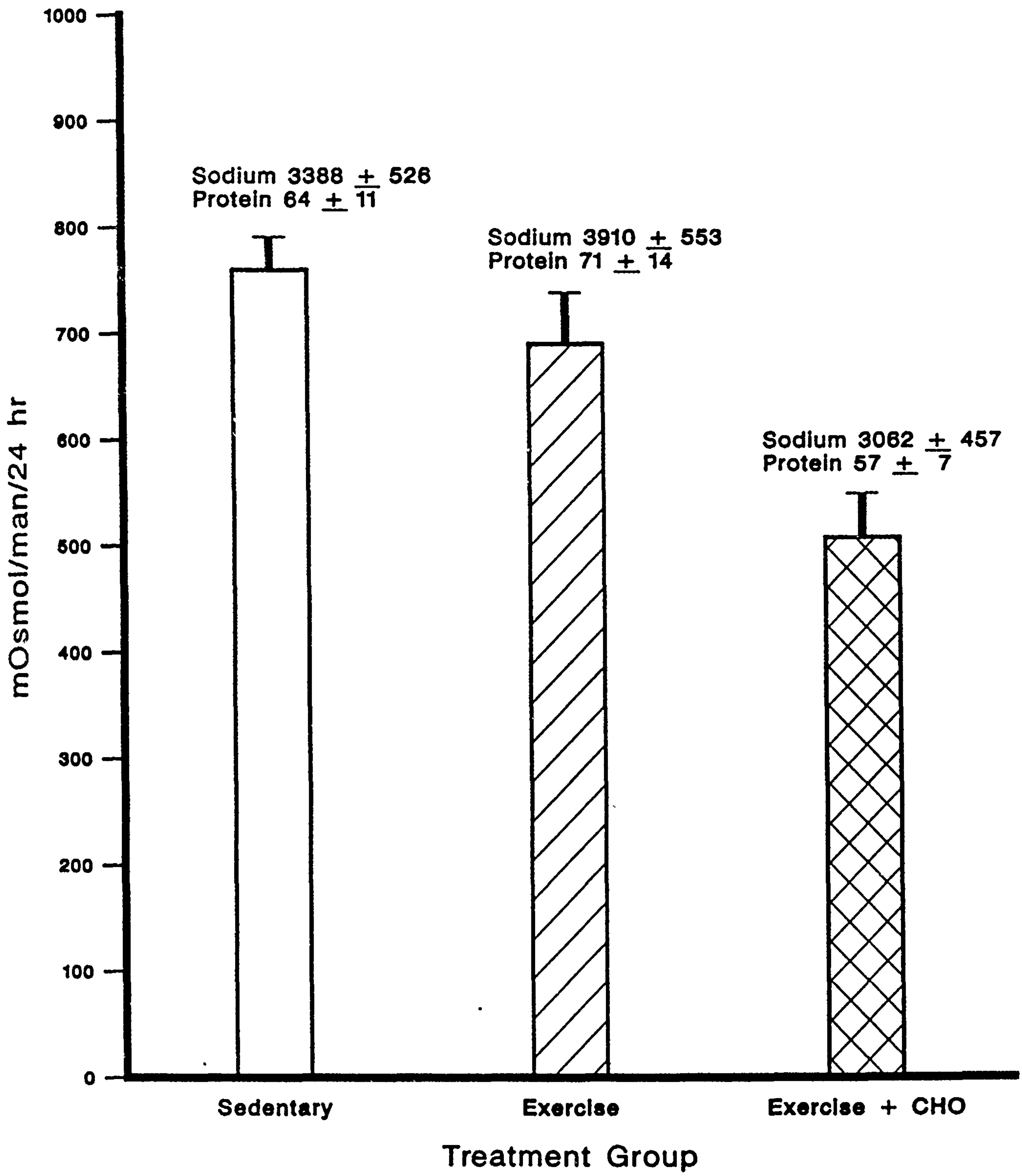
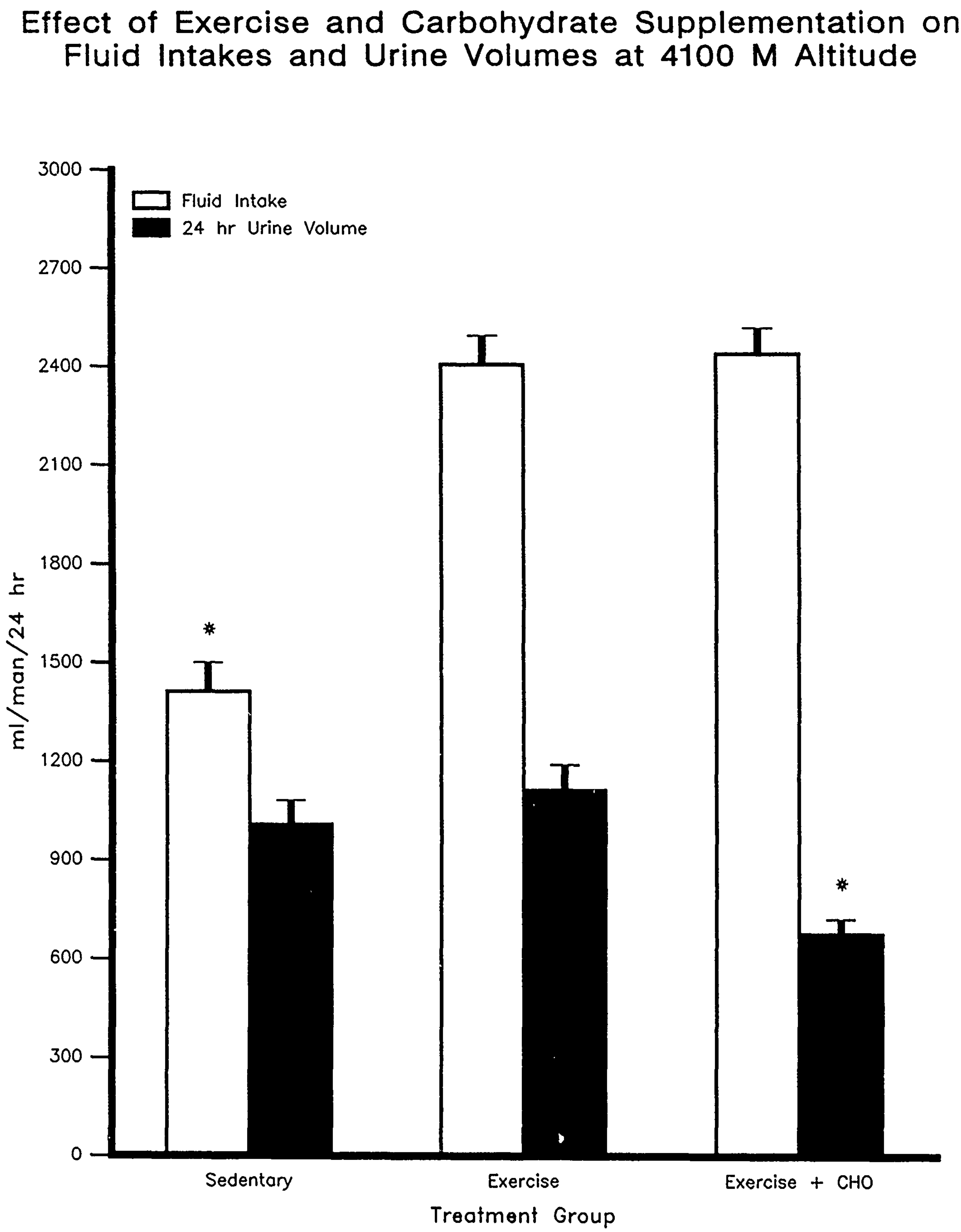


FIGURE 4



Effect of Exercise and Carbohydrate Supplementation on
Fluid Intakes and Urine Volumes at 4100 M Altitude
Fluid Intake
24 hr Urine Volume
ml/man/24 hr
3000
2700
2400
2100
1800
1500
1200
900
600
300
0
*
*
Sedentary
Exercise
Exercise + CHO
Treatment Group

FIGURE 5

Effect of Carbohydrate Supplement on Nitrogen Balance at Sea Level and 4100 Meters Elevation

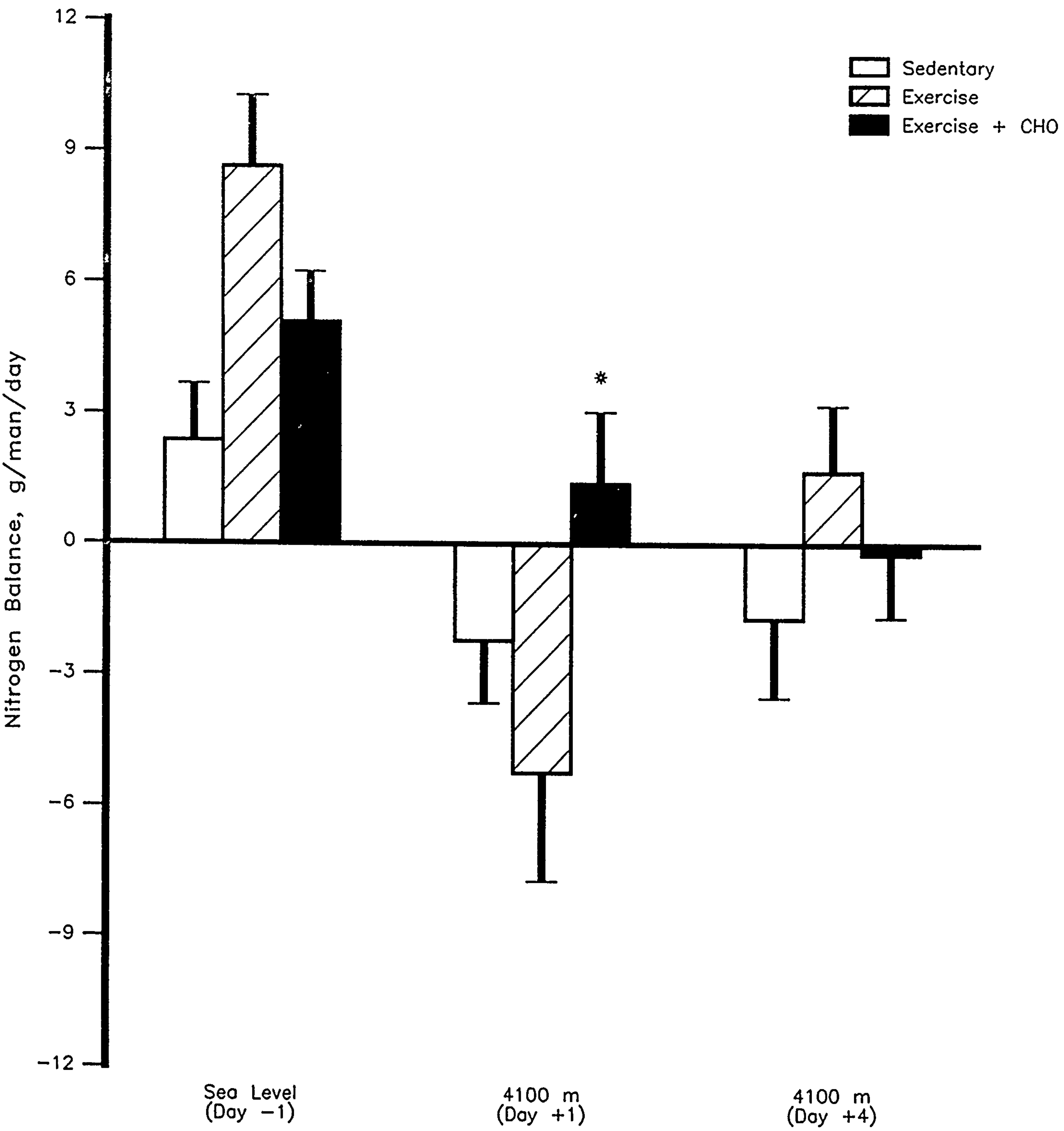


FIGURE 6

SERUM BETA HYDROXYBUTYRATE AT SEA LEVEL AND AT 4100 METERS ELEVATION

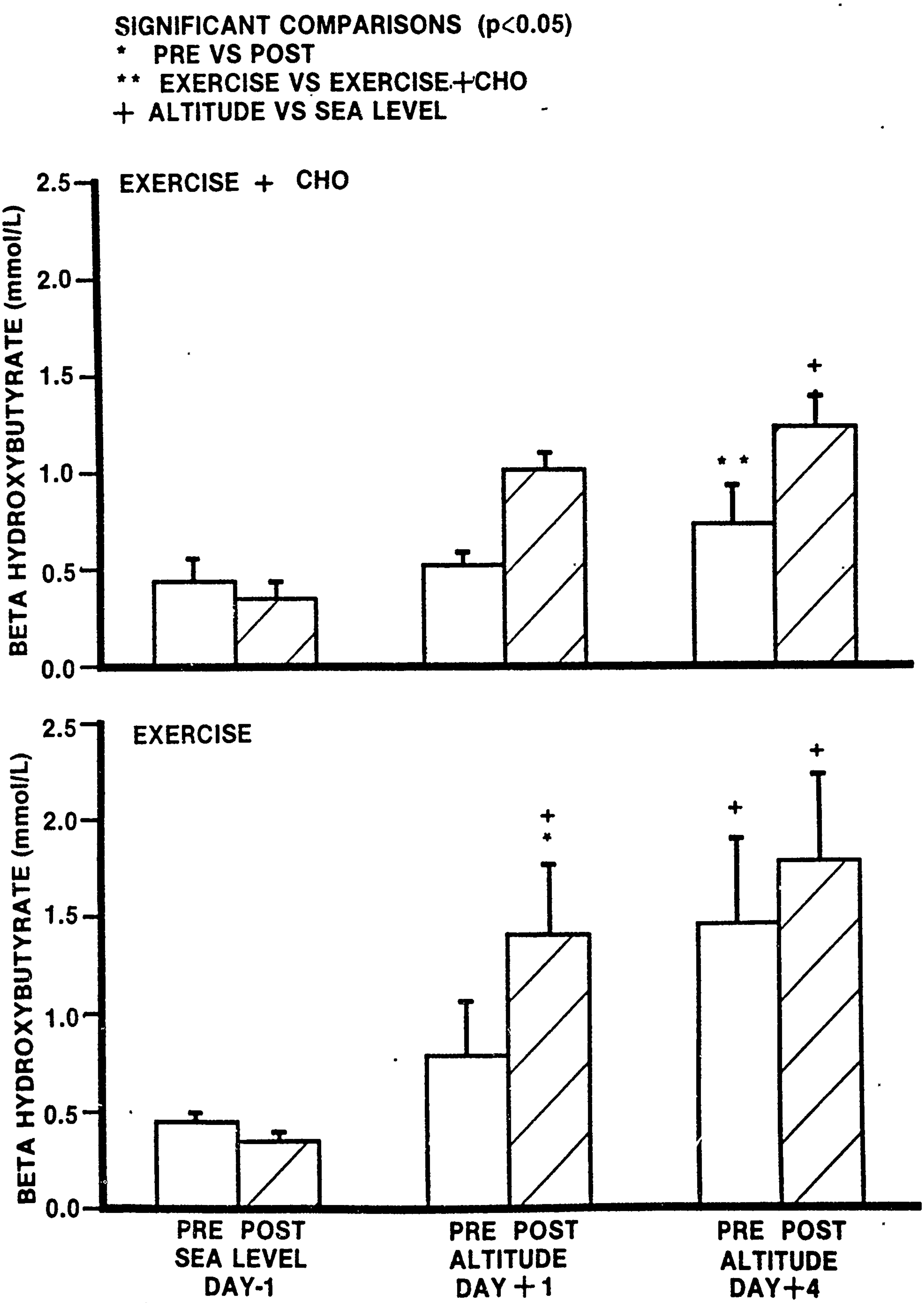
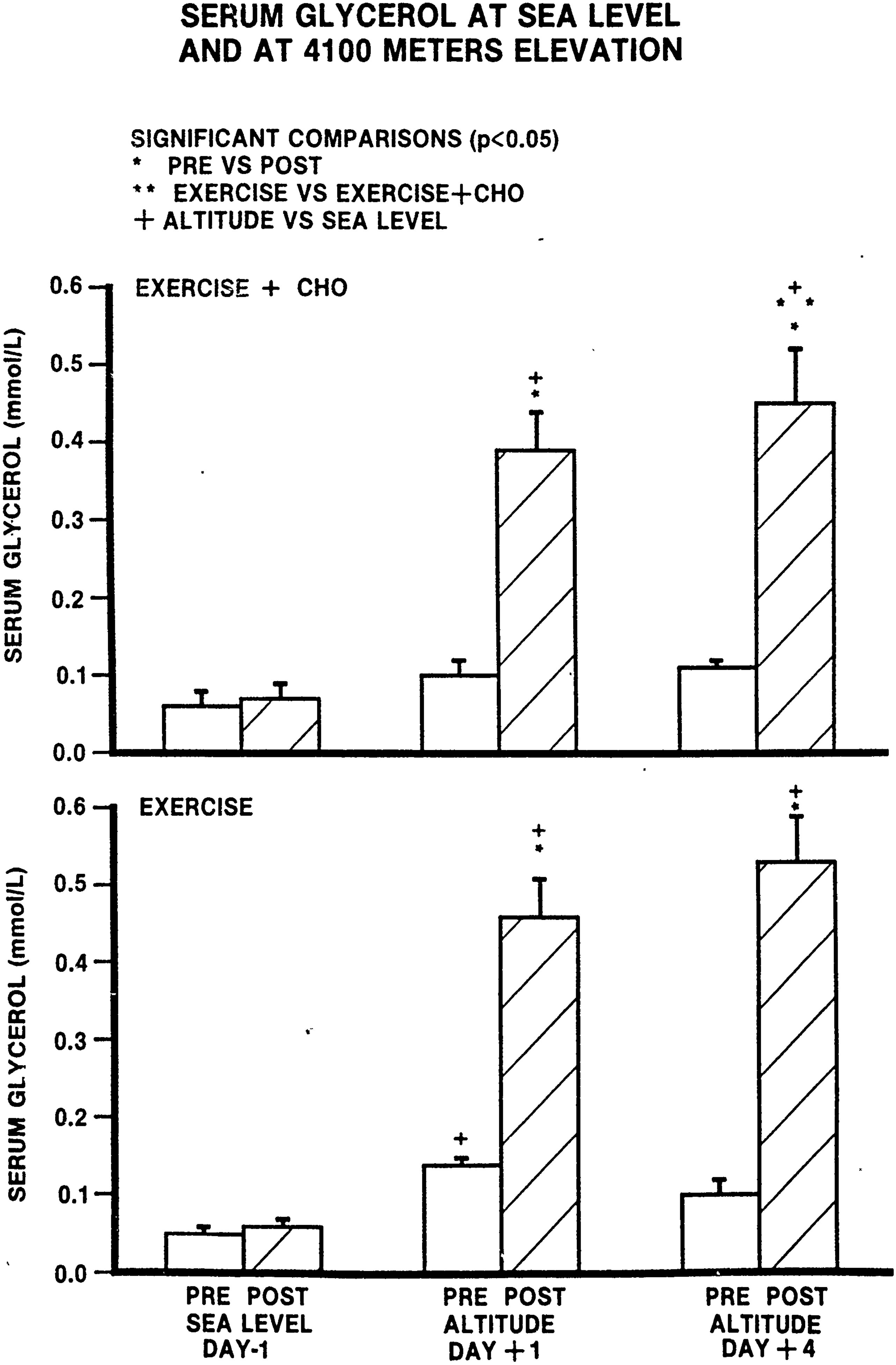


FIGURE 7



SERUM GLYCEROL AT SEA LEVEL AND AT 4100 METERS ELEVATION
SIGNIFICANT COMPARISONS (p<0.05)
* PRE VS POST
** EXERCISE VS EXERCISE+CHO
+ ALTITUDE VS SEA LEVEL
EXERCISE + CHO
EXERCISE
SERUM GLYCEROL (mmol/L)
0.6
0.5
0.4
0.3
0.2
0.1
0.0
PRE POST
SEA LEVEL
DAY-1
PRE POST
ALTITUDE
DAY +1
PRE POST
ALTITUDE
DAY +4

FIGURE 8

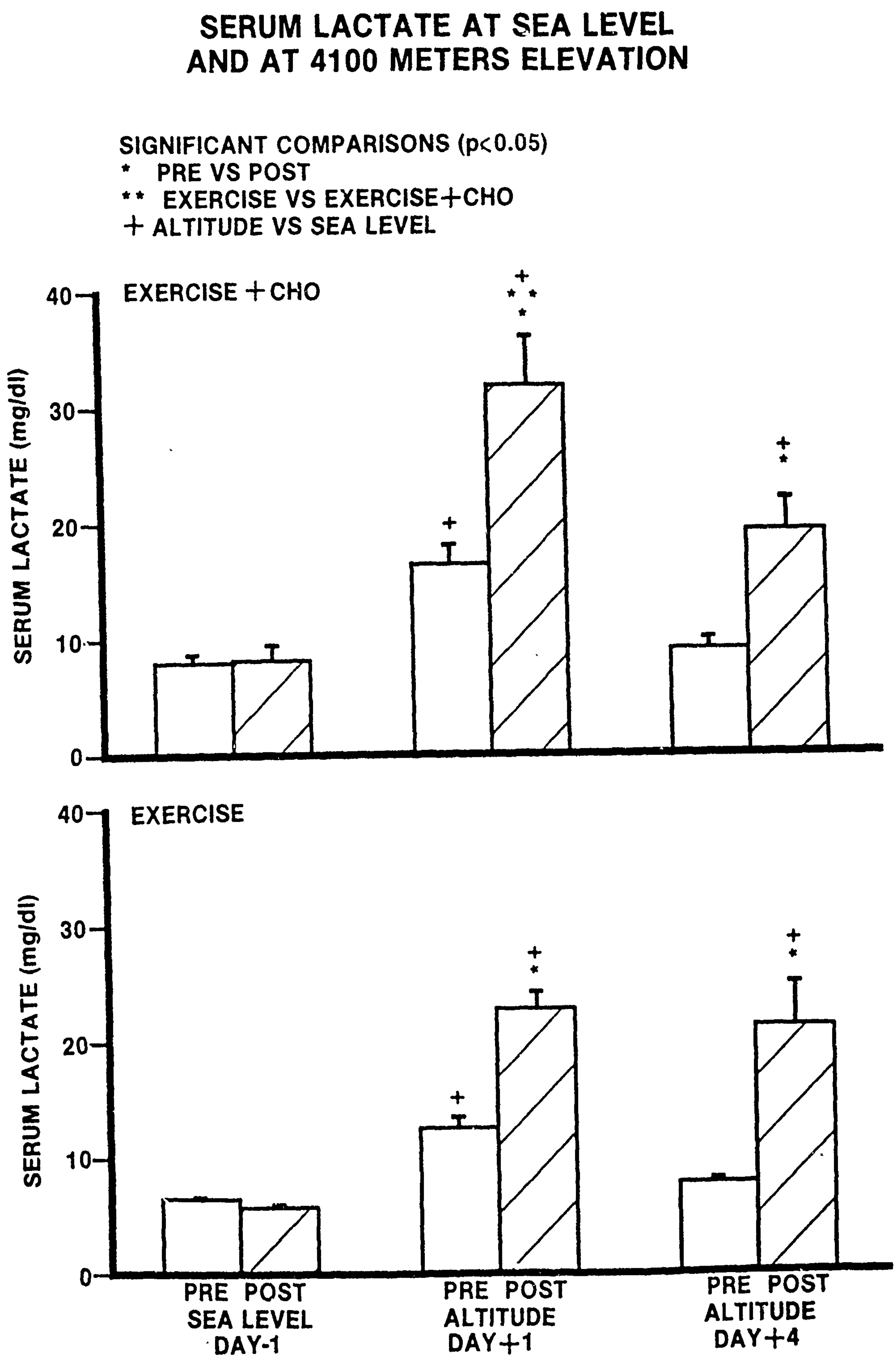

SERUM LACTATE AT SEA LEVEL
AND AT 4100 METERS ELEVATION
SIGNIFICANT COMPARISONS (p<0.05)
* PRE VS POST
** EXERCISE VS EXERCISE+CHO
+ ALTITUDE VS SEA LEVEL
EXERCISE + CHO
SERUM LACTATE (mg/dl)
40
30
20
10
0
EXERCISE
SERUM LACTATE (mg/dl)
40
30
20
10
0
PRE POST
SEA LEVEL
DAY-1
PRE POST
ALTITUDE
DAY+1
PRE POST
ALTITUDE
DAY+4

FIGURE 9

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Appendix 1

MRE Food Record Card

TAMC Form 492(OT), 1 Apr 85

MAUNA KEA III

SUBJECT NO. ______

Privacy Act Covered by the Consent Agreement

FOOD RECORD - MRE

Name ____
Last First Middle Initial

Date (Circle date)	Tues	Wed	Thurs	Fri	Sat	Sun	Mon	Tue	Wed	Thurs	Fri	Sat
	7/16	7/17	7/18	7/19	7/20	7/21	7/22	7/23	7/24	7/25	7/26	7/27

1. Breakfast ___ Lunch ___ Supper ___ Snack ___

2. Please mark the number of items you ate and circle the number on the right to show how much you ate.

Entree	Number of Items Eaten	Amount Eaten			
Beef w/barbeque sauce	____	1/4	1/2	3/4	all
Beef w/gravy	____	1/4	1/2	3/4	all
Beef w/spiced sauce	____	1/4	1/2	3/4	all
Beef patties	____	1/4	1/2	3/4	all
Beef stew	____	1/4	1/2	3/4	all
Chicken ala king	____	1/4	1/2	3/4	all
Frankfurters	____	1/4	1/2	3/4	all
Ham/chicken loaf	____	1/4	1/2	3/4	all
Ham slices	____	1/4	1/2	3/4	all
Meatballs w/barbeque sce	____	1/4	1/2	3/4	all
Pork sausage patties	____	1/4	1/2	3/4	all
Turkey w/gravy	____	1/4	1/2	3/4	all
STARCH					
Crackers	____	1/4	1/2	3/4	all
Beans w/tomato sauce	____	1/4	1/2	3/4	all
Potato patty	____	1/4	1/2	3/4	all
SPREAD					
Cheese	____	1/4	1/2	3/4	all
Jelly	____	1/4	1/2	3/4	all
Peanut butter	____	1/4	1/2	3/4	all
FRUIT					
Applesauce	____	1/4	1/2	3/4	all
Mixed fruits	____	1/4	1/2	3/4	all
Peaches	____	1/4	1/2	3/4	all
DESSERT					
Brownie	____	1/4	1/2	3/4	all
Cherry nut cake	____	1/4	1/2	3/4	all
Chocolate-covered cookie	____	1/4	1/2	3/4	all
Fruitcake	____	1/4	1/2	3/4	all
Maple nut cake	____	1/4	1/2	3/4	all
Orange nut cake	____	1/4	1/2	3/4	all
Pineapple nut cake	____	1/4	1/2	3/4	all
Chocolate nut cake	____	1/4	1/2	3/4	all

CONTINUED ON OTHER SIDE

BEVERAGE

Cocoa powder (Green packet from MRE)	____	1/4	1/2	3/4	all
Coffee	____	1/4	1/2	3/4	all
Cream substitute	____	1/4	1/2	3/4	all
Sugar	____	1/4	1/2	3/4	all

OTHER

Catsup	____	1/4	1/2	3/4	all
Gravy base (soup mix)	____	1/4	1/2	3/4	all
Candy (all types)	____	1/4	1/2	3/4	all

3. List other foods eaten, not from this menu pack, that you saved from an earlier meal or received from someone else. Circle the number on the right to show how much you ate.

FOOD	AMOUNT EATEN			
____________________	1/4	1/2	3/4	all
____________________	1/4	1/2	3/4	all
____________________	1/4	1/2	3/4	all
____________________	1/4	1/2	3/4	all
____________________	1/4	1/2	3/4	all
____________________	1/4	1/2	3/4	all
____________________	1/4	1/2	3/4	all

4. Circle the number of cups of Kool-Aid consumed between the completion of your last meal and this meal.

Kool-Aid 1 2 3 4 5

5. Circle the number of packets of supplemental hot chocolate consumed between the completion of your last meal and this meal.

Hot Chocolate 1 2 3 4 5
(clear plastic bag)

6. Circle the number of cups of water consumed between the completion of your last meal and this meal.

Water 1 2 3 4 5

7. Comments:

____ I did not eat today.
____ I was not very hungry.
____ I have a headache.
____ I am nauseous.
____ I vomited before this meal.
____ I vomited after this meal.
____ I feel fine.

Please return the card to your squad leader when you are through filling it out, <u>even if you did not eat today</u>.

Thank you, the information you have provided will help the Army develop better field rations for you and fellow soldiers in the future.

Appendix 2

Mean Daily Nutrient Intakes

Note:

July 16 = Day -2
July 17 = Day -1
July 18 = Day 0
July 19 = Day +1
July 20 = Day +2
July 21 = Day +3
July 22 = Day +4

Table 1
Mean Daily Intake of Energy and Nutrients : Daily Basis
For Each Group

GROUP : A (EXERCISE)

	DATE					
	16JUL		17JUL		18JUL	
	Daily Mean Intake	N	Daily Mean Intake	N	Daily Mean Intake	N
PROTEIN, g	115	8	134	8	91	8
FAT, g	123	8	132	8	91	8
CARBOHYDRATES, g	289	8	324	8	279	8
K CALORIES	2735	8	3028	8	2307	8
CALCIUM, mg	620	8	710	8	887	8
PHOSPHORUS, mg	1431	8	1648	8	1458	8
IRON, mg	16.6	8	19.2	8	15.9	8
SODIUM, mg	6020	8	7120	8	5057	8
POTASSIUM, mg	2467	8	2889	8	2896	8
MAGNESIUM, mg	281	8	304	8	274	8
TOTAL VIT. A, IU	4678	8	4063	8	4410	8
VIT. C, mg	94	8	97	8	85	8
THIAMIN, mg	4.5	8	4.8	8	3.9	8
RIBOFLAVIN, mg	2.5	8	2.9	8	2.6	8
NIACIN, mg	28.6	8	31.4	8	19.0	8
PYRIDOXINE, mg	2.1	8	2.5	8	2.6	8
WATER FROM FOOD, g	370	8	440	8	275	8
TOTAL FOOD, g	924	8	1059	8	766	8
TOTAL FOOD, DRY WT	554	8	620	8	491	8

Table 2
Mean Daily Intake of Energy and Nutrients : Daily Basis
For Each Group

GROUP : A (EXERCISE)

	DATE					
	19JUL		20JUL		21JUL	
	Daily Mean Intake	N	Daily Mean Intake	N	Daily Mean Intake	N
PROTEIN, g	51	8	74	8	79	8
FAT, g	61	8	85	8	84	8
CARBOHYDRATES, g	154	8	168	8	184	8
K CALORIES	1376	8	1746	8	1819	8
CALCIUM, mg	496	8	521	8	473	8
PHOSPHORUS, mg	758	8	991	8	1021	8
IRON, mg	7.7	8	10.1	8	9.9	8
SODIUM, mg	2899	8	4190	8	3737	8
POTASSIUM, mg	1260	8	1566	8	1683	8
MAGNESIUM, mg	157	8	188	8	206	8
TOTAL VIT. A, IU	3299	8	5484	8	5464	8
VIT. C, mg	71	8	112	8	124	8
THIAMIN, mg	3.6	8	4.4	8	4.5	8
RIBOFLAVIN, mg	1.7	8	1.8	8	1.8	8
NIACIN, mg	15.7	8	19.6	8	23.0	8
PYRIDOXINE, mg	1.4	8	2.3	8	2.1	8
WATER FROM FOOD, g	104	8	158	8	157	8
TOTAL FOOD, g	386	8	506	8	525	8
TOTAL FOOD, DRY WT	282	8	348	8	368	8

Table 3
Mean Daily Intake of Energy and Nutrients : Daily Basis
For Each Group

GROUP : A (EXERCISE)

	DATE	
	22JUL	
	Daily Mean Intake	N
PROTEIN, g	82	8
FAT, g	100	8
CARBOHYDRATES, g	241	8
K CALORIES	2205	8
CALCIUM, mg	738	8
PHOSPHORUS, mg	1219	8
IRON, mg	12.9	8
SODIUM, mg	4812	8
POTASSIUM, mg	2114	8
MAGNESIUM, mg	227	8
TOTAL VIT. A, IU	6387	8
VIT. C, mg	127	8
THIAMIN, mg	5.4	8
RIBOFLAVIN, mg	2.5	8
NIACIN, mg	20.6	8
PYRIDOXINE, mg	2.8	8
WATER FROM FOOD, g	229	8
TOTAL FOOD, g	678	8
TOTAL FOOD, DRY WT	449	8

Table 4
Mean Daily Intake of Energy and Nutrients : Daily Basis
For Each Group

GROUP : B (EXERCISE + CHO)

	DATE					
	16JUL		17JUL		18JUL	
	Daily Mean Intake	N	Daily Mean Intake	N	Daily Mean Intake	N
PROTEIN, g	64	6	96	6	79	6
FAT, g	64	6	99	6	72	6
CARBOHYDRATES, g	246	6	378	6	515	6
K CALORIES	1816	6	2785	6	3013	6
CALCIUM, mg	264	6	439	6	729	6
PHOSPHORUS, mg	764	6	1192	6	1282	6
IRON, mg	8.6	6	14.2	6	10.7	6
SODIUM, mg	3131	6	5123	6	3622	6
POTASSIUM, mg	1405	6	2481	6	2642	6
MAGNESIUM, mg	146	6	239	6	208	6
TOTAL VIT. A, IU	2670	6	5163	6	6244	6
VIT. C, mg	44	6	91	6	131	6
THIAMIN, mg	2.3	6	3.6	6	3.2	6
RIBOFLAVIN, mg	1.4	6	1.9	6	2.1	6
NIACIN, mg	15.5	6	21.8	6	15.9	6
PYRIDOXINE, mg	0.9	6	1.9	6	3.0	6
WATER FROM FOOD, g	200	6	355	6	223	6
TOTAL FOOD, g	530	6	873	6	761	6
TOTAL FOOD, DRY WT	330	6	518	6	538	6

Table 5
Mean Daily Intake of Energy and Nutrients : Daily Basis
For Each Group

GROUP : B (EXERCISE + CHO)

	DATE					
	19JUL		20JUL		21JUL	
	Daily Mean Intake	N	Daily Mean Intake	N	Daily Mean Intake	N
PROTEIN, g	59	6	54	6	62	6
FAT, g	40	6	55	6	66	6
CARBOHYDRATES, g	420	6	397	6	412	6
K CALORIES	2262	6	2293	6	2489	6
CALCIUM, mg	485	6	378	6	404	6
PHOSPHORUS, mg	886	6	785	6	845	6
IRON, mg	6.4	6	8.4	6	8.4	6
SODIUM, mg	2702	6	2980	6	3301	6
POTASSIUM, mg	1752	6	1372	6	1498	6
MAGNESIUM, mg	129	6	142	6	149	6
TOTAL VIT. A, IU	2626	6	3168	6	3784	6
VIT. C, mg	51	6	92	6	93	6
THIAMIN, mg	1.5	6	2.4	6	2.8	6
RIBOFLAVIN, mg	1.5	6	1.1	6	1.4	6
NIACIN, mg	11.5	6	14.4	6	15.4	6
PYRIDOXINE, mg	0.9	6	1.6	6	1.5	6
WATER FROM FOOD, g	140	6	168	6	179	6
TOTAL FOOD, g	500	6	537	6	586	6
TOTAL FOOD, DRY WT	359	6	369	6	406	6

Table 6
Mean Daily Intake of Energy and Nutrients : Daily Basis
For Each Group

GROUP : B (EXERCISE + CHO)

	DATE	
	22JUL	
	Daily Mean Intake	N
PROTEIN, g	55	6
FAT, g	55	6
CARBOHYDRATES, g	387	6
K CALORIES	2255	6
CALCIUM, mg	446	6
PHOSPHORUS, mg	847	6
IRON, mg	8.6	6
SODIUM, mg	3267	6
POTASSIUM, mg	1392	6
MAGNESIUM, mg	119	6
TOTAL VIT. A, IU	2521	6
VIT. C, mg	69	6
THIAMIN, mg	2.7	6
RIBOFLAVIN, mg	1.5	6
NIACIN, mg	12.5	6
PYRIDOXINE, mg	1.6	6
WATER FROM FOOD, g	172	6
TOTAL FOOD, g	547	6
TOTAL FOOD, DRY WT	375	6

Table 7
Mean Daily Intake of Energy and Nutrients : Daily Basis
For Each Group

GROUP : C (SEDENTARY)

	DATE					
	16JUL		17JUL		18JUL	
	Daily Mean Intake	N	Daily Mean Intake	N	Daily Mean Intake	N
PROTEIN, g	97	10	98	10	100	10
FAT, g	99	10	122	10	84	10
CARBOHYDRATES, g	211	10	265	10	218	10
K CALORIES	2138	10	2559	10	2045	10
CALCIUM, mg	605	10	563	10	857	10
PHOSPHORUS, mg	1431	10	1426	10	1583	10
IRON, mg	13.4	10	13.8	10	14.4	10
SODIUM, mg	4859	10	5337	10	4638	10
POTASSIUM, mg	2037	10	2316	10	2862	10
MAGNESIUM, mg	221	10	255	10	263	10
TOTAL VIT. A, IU	6255	10	7472	10	4832	10
VIT. C, mg	118	10	121	10	103	10
THIAMIN, mg	4.2	10	4.1	10	3.3	10
RIBOFLAVIN, mg	2.0	10	2.0	10	2.4	10
NIACIN, mg	21.1	10	21.8	10	20.5	10
PYRIDOXINE, mg	2.9	10	2.9	10	2.4	10
WATER FROM FOOD, g	363	10	344	10	315	10
TOTAL FOOD, g	794	10	854	10	747	10
TOTAL FOOD, DRY WT	431	10	510	10	432	10

Table 8
Mean Daily Intake of Energy and Nutrients : Daily Basis
For Each Group

GROUP : C (SEDENTARY)

	DATE					
	19JUL		20JUL		21JUL	
	Daily Mean Intake	N	Daily Mean Intake	N	Daily Mean Intake	N
PROTEIN, g	69	10	59	10	57	10
FAT, g	72	10	68	10	58	10
CARBOHYDRATES, g	174	10	160	10	153	10
K CALORIES	1626	10	1497	10	1372	10
CALCIUM, mg	492	10	422	10	310	10
PHOSPHORUS, mg	1100	10	878	10	827	10
IRON, mg	9.8	10	9.1	10	8.2	10
SODIUM, mg	3820	10	3077	10	3083	10
POTASSIUM, mg	1674	10	1619	10	1479	10
MAGNESIUM, mg	158	10	161	10	142	10
TOTAL VIT. A, IU	3264	10	3617	10	3546	10
VIT. C, mg	67	10	54	10	73	10
THIAMIN, mg	2.2	10	2.0	10	1.7	10
RIBOFLAVIN, mg	1.5	10	1.4	10	1.0	10
NIACIN, mg	13.8	10	12.0	10	12.3	10
PYRIDOXINE, mg	1.5	10	1.3	10	1.5	10
WATER FROM FOOD, g	238	10	216	10	237	10
TOTAL FOOD, g	573	10	520	10	522	10
TOTAL FOOD, DRY WT	334	10	304	10	285	10

Table 9
Mean Daily Intake of Energy and Nutrients : Daily Basis
For Each Group

GROUP : C (SEDENTARY)

	DATE	
	22JUL	
	Daily Mean Intake	N
PROTEIN, g	73	10
FAT, g	72	10
CARBOHYDRATES, g	151	10
K CALORIES	1556	10
CALCIUM, mg	413	10
PHOSPHORUS, mg	990	10
IRON, mg	9.8	10
SODIUM, mg	3573	10
POTASSIUM, mg	1747	10
MAGNESIUM, mg	170	10
TOTAL VIT. A, IU	4000	10
VIT. C, mg	99	10
THIAMIN, mg	2.6	10
RIBOFLAVIN, mg	1.4	10
NIACIN, mg	15.6	10
PYRIDOXINE, mg	2.0	10
WATER FROM FOOD, g	215	10
TOTAL FOOD, g	532	10
TOTAL FOOD, DRY WT	316	10

Table 10
Intake of Energy and Nutrients: Rest, Sea Level Period I
Group Means, Standard Deviations, and Standard Error of the Means

	GROUP							
	A: 7/16-17 (EX)				B: 7/16-17 (EX+CHO)			
	N	Daily Mean Intake	STD DEV	STD ERR	N	Daily Mean Intake	STD DEV	STD ERR
PROTEIN, g	8	124.3	43.8	15.5	6	80.1	14.3	5.8
FAT, g	8	127.7	38.0	13.4	6	81.2	19.4	7.9
CARBOHYDRATES, g	8	306.6	131.3	46.4	6	312.4	63.9	26.1
K CALORIES	8	2881.5	982.7	347.4	6	2300.4	359.9	146.9
CALCIUM, mg	8	665.1	288.0	101.8	6	351.5	159.9	65.3
PHOSPHORUS, mg	8	1539.4	608.6	215.2	6	978.0	202.3	82.6
IRON, mg	8	17.9	7.4	2.6	6	11.4	2.4	1.0
SODIUM, mg	8	6569.9	2158.4	763.1	6	4126.9	1067.1	435.7
POTASSIUM, mg	8	2677.9	1251.5	442.5	6	1942.8	533.0	217.6
MAGNESIUM, mg	8	292.6	126.5	44.7	6	192.2	71.7	29.3
TOTAL VIT. A, IU	8	4370.6	2476.4	875.5	6	3916.7	1715.5	700.3
VIT. C, mg	8	95.3	41.7	14.8	6	67.0	31.1	12.7
THIAMIN, mg	8	4.6	2.2	0.8	6	2.9	1.3	0.5
RIBOFLAVIN, mg	8	2.7	0.9	0.3	6	1.6	0.5	0.2
NIACIN, mg	8	30.0	10.7	3.8	6	18.7	4.6	1.9
PYRIDOXINE, mg	8	2.3	1.3	0.5	6	1.4	0.7	0.3
WATER FROM FOOD, g	8	404.9	221.5	78.3	6	277.4	95.4	38.9
TOTAL FOOD, g	8	991.6	397.9	140.7	6	701.2	99.7	40.7
TOTAL FOOD, DRY WT	8	586.7	210.3	74.4	6	423.8	75.4	30.8

Table 11
Intake of Energy and Nutrients: Rest, Sea Level Period I
Group Means, Standard Deviations, and Standard Error of the Means

	GROUP (SED)			
	C: 7/16-17			
	N	Daily Mean Intake	STD DEV	STD ERR
PROTEIN, g	10	97.4	22.0	7.0
FAT, g	10	110.5	27.3	8.6
CARBOHYDRATES, g	10	238.0	61.6	19.5
K CALORIES	10	2348.6	449.5	142.1
CALCIUM, mg	10	583.7	132.6	41.9
PHOSPHORUS, mg	10	1428.3	183.3	58.0
IRON, mg	10	13.6	2.2	0.7
SODIUM, mg	10	5098.0	625.9	197.9
POTASSIUM, mg	10	2176.8	432.1	136.6
MAGNESIUM, mg	10	238.1	54.1	17.1
TOTAL VIT. A, IU	10	6863.3	2732.4	864.0
VIT. C, mg	10	119.6	42.4	13.4
THIAMIN, mg	10	4.2	1.2	0.4
RIBOFLAVIN, mg	10	2.0	0.4	0.1
NIACIN, mg	10	21.4	6.2	2.0
PYRIDOXINE, mg	10	2.9	1.2	0.4
WATER FROM FOOD, g	10	353.4	81.0	25.6
TOTAL FOOD, g	10	823.9	109.9	34.8
TOTAL FOOD, DRY WT	10	470.5	83.0	26.3

Table 12
Intake of Energy and Nutrients: Rest, Sea Level Period I
Combined Group Means, Standard Deviations, and Standard Error of the Means

	Groups Combined: 7/16-17			
	N	Daily Mean Intake	STD DEV	STD ERR
PROTEIN, g	24	102.0	33.5	6.8
FAT, g	24	108.9	33.7	6.9
CARBOHYDRATES, g	24	279.4	94.4	19.3
K CALORIES	24	2514.2	687.0	140.2
CALCIUM, mg	24	552.8	230.3	47.0
PHOSPHORUS, mg	24	1352.8	431.3	88.0
IRON, mg	24	14.5	5.2	1.1
SODIUM, mg	24	5345.8	1659.6	338.8
POTASSIUM, mg	24	2285.3	837.2	170.9
MAGNESIUM, mg	24	244.8	93.1	19.0
TOTAL VIT. A, IU	24	5295.7	2699.9	551.1
VIT. C, mg	24	98.4	43.6	8.9
THIAMIN, mg	24	4.0	1.7	0.3
RIBOFLAVIN, mg	24	2.1	0.7	0.2
NIACIN, mg	24	23.6	8.8	1.8
PYRIDOXINE, mg	24	2.3	1.2	0.3
WATER FROM FOOD, g	24	351.6	148.0	30.2
TOTAL FOOD, g	24	849.1	261.0	53.3
TOTAL FOOD, DRY WT	24	497.6	148.0	30.2

Table 13
Intake of Energy and Nutrients: Altitude Period II
Group Means, Standard Deviations, and Standard Error of the Means

	GROUP							
	A: 7/19-22 (EX)				B: 7/19-22 (EX+CHO)			
	N	Daily Mean Intake	STD DEV	STD ERR	N	Daily Mean Intake	STD DEV	STD ERR
PROTEIN, g	8	71.3	40.3	14.2	6	57.4	16.1	6.6
FAT, g	8	82.3	44.1	15.6	6	53.9	14.1	5.7
CARBOHYDRATES, g	8	186.6	76.1	26.9	6	403.8	111.5	45.5
K CALORIES	8	1786.5	814.5	288.0	6	2324.5	527.4	215.3
CALCIUM, mg	8	556.9	238.9	84.4	6	428.5	189.6	77.4
PHOSPHORUS, mg	8	997.1	549.2	194.2	6	841.0	277.0	113.1
IRON, mg	8	10.1	4.2	1.5	6	8.0	2.3	0.9
SODIUM, mg	8	3909.5	1565.3	553.4	6	3062.3	1118.7	456.7
POTASSIUM, mg	8	1655.9	905.8	320.2	6	1503.4	416.9	170.2
MAGNESIUM, mg	8	194.7	140.8	49.8	6	134.9	34.4	14.1
TOTAL VIT. A, IU	8	5158.5	4196.4	1483.7	6	3024.7	1263.1	515.7
VIT. C, mg	8	108.7	66.0	23.3	6	76.1	19.6	8.0
THIAMIN, mg	8	4.5	2.4	0.8	6	2.4	0.8	0.3
RIBOFLAVIN, mg	8	2.0	0.9	0.3	6	1.4	0.5	0.2
NIACIN, mg	8	19.7	13.1	4.6	6	13.5	4.0	1.6
PYRIDOXINE, mg	8	2.1	1.1	0.4	6	1.4	0.5	0.2
WATER FROM FOOD, g	8	161.8	95.6	33.8	6	164.9	52.0	21.2
TOTAL FOOD, g	8	523.6	242.9	85.9	6	542.1	130.0	53.1
TOTAL FOOD, DRY WT	8	361.8	157.4	55.6	6	377.3	89.2	36.4

Table 14
Intake of Energy and Nutrients: Altitude Period II
Group Means, Standard Deviations, and Standard Error of the Means

	GROUP			
	C: 7/19-22 (SED)			
	N	Daily Mean Intake	STD DEV	STD ERR
PROTEIN, g	10	64.4	35.4	11.2
FAT, g	10	67.2	43.6	13.8
CARBOHYDRATES, g	10	159.4	96.7	30.6
K CALORIES	10	1512.7	884.5	279.7
CALCIUM, mg	10	409.6	281.4	89.0
PHOSPHORUS, mg	10	948.7	556.8	176.1
IRON, mg	10	9.2	5.2	1.6
SODIUM, mg	10	3388.2	1663.5	526.1
POTASSIUM, mg	10	1629.5	843.5	266.7
MAGNESIUM, mg	10	157.9	91.8	29.0
TOTAL VIT. A, IU	10	3606.9	1945.3	615.2
VIT. C, mg	10	73.4	39.1	12.4
THIAMIN, mg	10	2.1	1.4	0.4
RIBOFLAVIN, mg	10	1.4	0.8	0.3
NIACIN, mg	10	13.4	7.5	2.4
PYRIDOXINE, mg	10	1.6	0.9	0.3
WATER FROM FOOD, g	10	226.7	134.8	42.6
TOTAL FOOD, g	10	536.6	290.7	91.9
TOTAL FOOD, DRY WT	10	310.0	175.6	55.5

Table 15
Intake of Energy and Nutrients: Altitude Period II
Combined Group Means, Standard Deviations, and Standard Error of the Means

	Groups Combined: 7/19-22			
	N	Daily Mean Intake	STD DEV	STD ERR
PROTEIN, g	24	65.0	32.7	6.7
FAT, g	24	68.9	38.7	7.9
CARBOHYDRATES, g	24	229.6	137.2	28.0
K CALORIES	24	1807.0	822.3	167.9
CALCIUM, mg	24	463.4	246.5	50.3
PHOSPHORUS, mg	24	937.9	483.3	98.6
IRON, mg	24	9.2	4.2	0.9
SODIUM, mg	24	3480.5	1488.0	303.7
POTASSIUM, mg	24	1606.8	754.8	154.1
MAGNESIUM, mg	24	164.4	100.8	20.6
TOTAL VIT. A, IU	24	3978.5	2822.9	576.2
VIT. C, mg	24	85.8	47.8	9.7
THIAMIN, mg	24	3.0	2.0	0.4
RIBOFLAVIN, mg	24	1.6	0.8	0.2
NIACIN, mg	24	15.5	9.3	1.9
PYRIDOXINE, mg	24	1.7	0.9	0.2
WATER FROM FOOD, g	24	189.6	107.3	21.9
TOTAL FOOD, g	24	533.7	234.0	47.8
TOTAL FOOD, DRY WT	24	344.1	149.1	30.4

Table 16
Intake of Energy and Nutrients: Entire Experiment
Group Means, Standard Deviations, and Standard Error of the Means

	GROUP							
	A: 7/16-22 (EX)				B: 7/16-22 (EX+CHO)			
	N	Daily Mean Intake	STD DEV	STD ERR	N	Daily Mean Intake	STD DEV	STD ERR
PROTEIN, g	8	89.2	33.2	11.7	6	67.0	15.2	6.2
FAT, g	8	96.5	30.7	10.9	6	64.3	15.6	6.4
CARBOHYDRATES, g	8	234.1	75.8	26.8	6	393.6	107.7	44.0
K CALORIES	8	2173.7	640.8	226.5	6	2415.9	522.3	213.2
CALCIUM, mg	8	634.9	216.7	76.6	6	449.5	190.1	77.6
PHOSPHORUS, mg	8	1217.9	437.2	154.6	6	943.2	274.8	112.2
IRON, mg	8	13.2	4.1	1.5	6	9.3	2.3	1.0
SODIUM, mg	8	4833.6	1321.4	467.2	6	3446.4	1118.7	456.7
POTASSIUM, mg	8	2125.1	773.2	273.4	6	1791.6	449.0	183.3
MAGNESIUM, mg	8	233.9	106.4	37.6	6	161.8	40.9	16.7
TOTAL VIT. A, IU	8	4826.5	3070.4	1085.5	6	3739.4	1632.6	666.5
VIT. C, mg	8	101.4	49.5	17.5	6	81.3	28.3	11.6
THIAMIN, mg	8	4.4	2.0	0.7	6	2.6	0.8	0.3
RIBOFLAVIN, mg	8	2.3	0.7	0.3	6	1.6	0.4	0.2
NIACIN, mg	8	22.6	10.4	3.7	6	15.3	3.6	1.5
PYRIDOXINE, mg	8	2.2	1.0	0.4	6	1.6	0.8	0.3
WATER FROM FOOD, g	8	247.4	97.8	34.6	6	205.4	47.0	19.2
TOTAL FOOD, g	8	691.9	215.8	76.3	6	618.9	105.2	43.0
TOTAL FOOD, DRY WT	8	444.5	131.0	46.3	6	413.5	89.7	36.6

Table 17
Intake of Energy and Nutrients: Entire Experiment
Group Means, Standard Deviations, and Standard Error of the Means

	GROUP			
	C: 7/16-22 (SED)			
	N	Daily Mean Intake	STD DEV	STD ERR
PROTEIN, g	10	78.9	24.2	7.7
FAT, g	10	82.0	30.0	9.5
CARBOHYDRATES, g	10	190.2	63.7	20.1
K CALORIES	10	1827.6	555.3	175.6
CALCIUM, mg	10	523.3	162.9	51.5
PHOSPHORUS, mg	10	1176.4	331.6	104.9
IRON, mg	10	11.2	3.0	0.9
SODIUM, mg	10	4055.3	1005.0	317.8
POTASSIUM, mg	10	1962.0	498.4	157.6
MAGNESIUM, mg	10	195.8	54.2	17.1
TOTAL VIT. A, IU	10	4712.2	1677.0	530.3
VIT. C, mg	10	90.8	30.7	9.7
THIAMIN, mg	10	2.9	0.9	0.3
RIBOFLAVIN, mg	10	1.7	0.4	0.1
NIACIN, mg	10	16.7	5.4	1.7
PYRIDOXINE, mg	10	2.1	0.8	0.3
WATER FROM FOOD, g	10	275.5	98.0	31.0
TOTAL FOOD, g	10	648.8	178.3	56.4
TOTAL FOOD, DRY WT	10	373.3	107.0	33.8

Table 18

Intake of Energy and Nutrients: Entire Experiment

Combined Group Means, Standard Deviations, and Standard Error of the Means

	Groups Combined: 7/16-22			
	N	Daily Mean Intake	STD DEV	STD ERR
PROTEIN, g	24	79.4	26.2	5.4
FAT, g	24	82.4	29.1	5.9
CARBOHYDRATES, g	24	255.7	113.4	23.1
K CALORIES	24	2090.1	604.2	123.3
CALCIUM, mg	24	542.1	194.7	39.7
PHOSPHORUS, mg	24	1131.9	361.0	73.7
IRON, mg	24	11.4	3.5	0.7
SODIUM, mg	24	4162.5	1222.3	249.5
POTASSIUM, mg	24	1973.8	582.8	119.0
MAGNESIUM, mg	24	200.0	75.8	15.5
TOTAL VIT. A, IU	24	4507.1	2181.0	445.2
VIT. C, mg	24	92.0	36.8	7.5
THIAMIN, mg	24	3.3	1.5	0.3
RIBOFLAVIN, mg	24	1.8	0.6	0.1
NIACIN, mg	24	18.3	7.5	1.5
PYRIDOXINE, mg	24	2.0	0.9	0.2
WATER FROM FOOD, g	24	248.6	89.1	18.2
TOTAL FOOD, g	24	655.7	172.8	35.3
TOTAL FOOD, DRY WT	24	407.1	111.6	22.8

Appendix 3

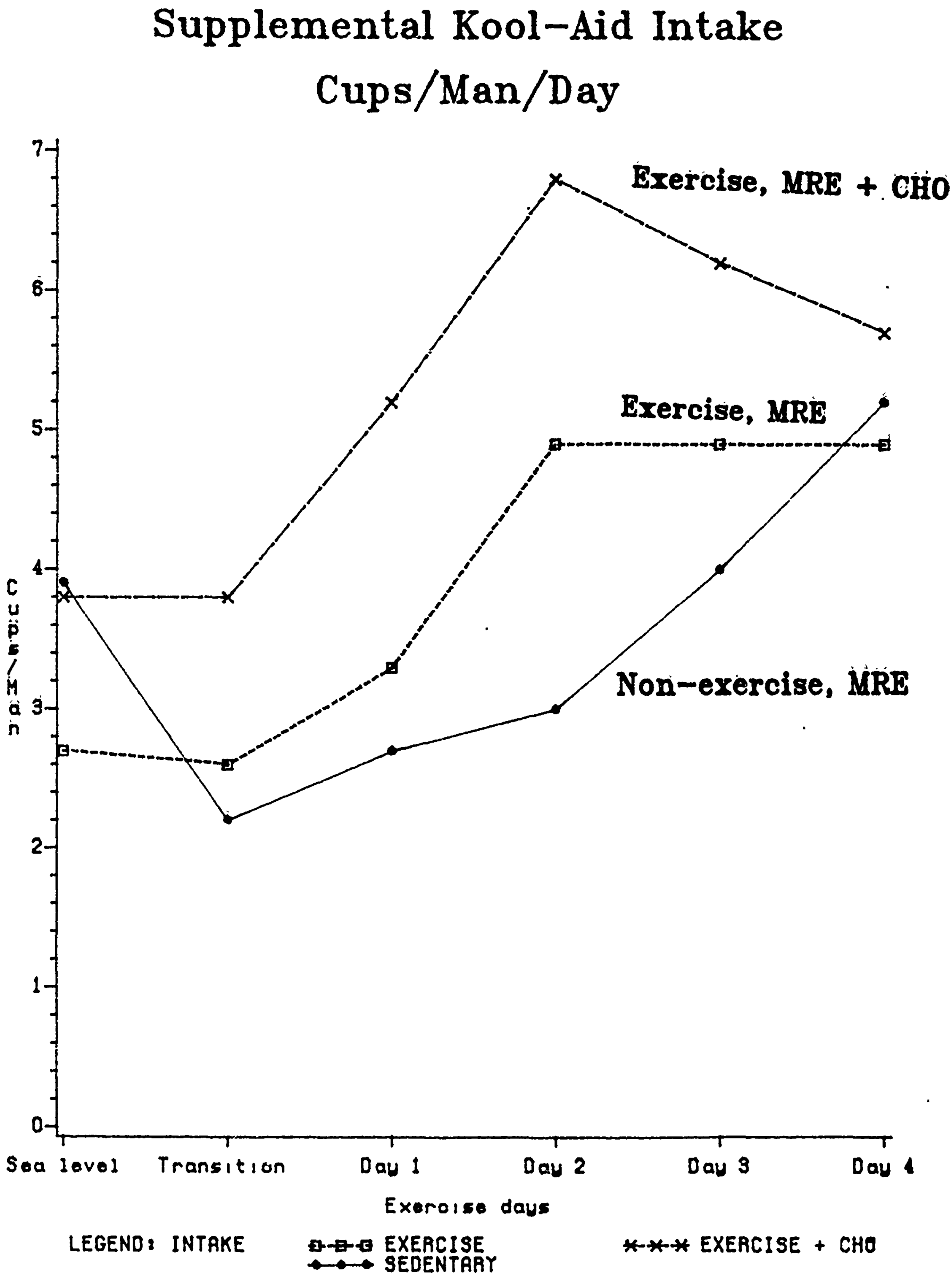
Mean Daily Carbohydrate and Energy

Intakes by Source

(EX + CHO Group)

Note:

July 16 = Day -2
July 17 = Day -1
July 18 = Day 0
July 19 = Day +1
July 20 = Day +2
July 21 = Day +3
July 22 = Day +4



Supplemental Kool-Aid Intake
Cups/Man/Day
Exercise, MRE + CHO
Exercise, MRE
Non-exercise, MRE
Cups/Man
7
6
5
4
3
2
1
0
Sea level
Transition
Day 1
Day 2
Day 3
Day 4
Exercise days
LEGEND: INTAKE
EXERCISE
SEDENTARY
EXERCISE + CHO

Figure 1

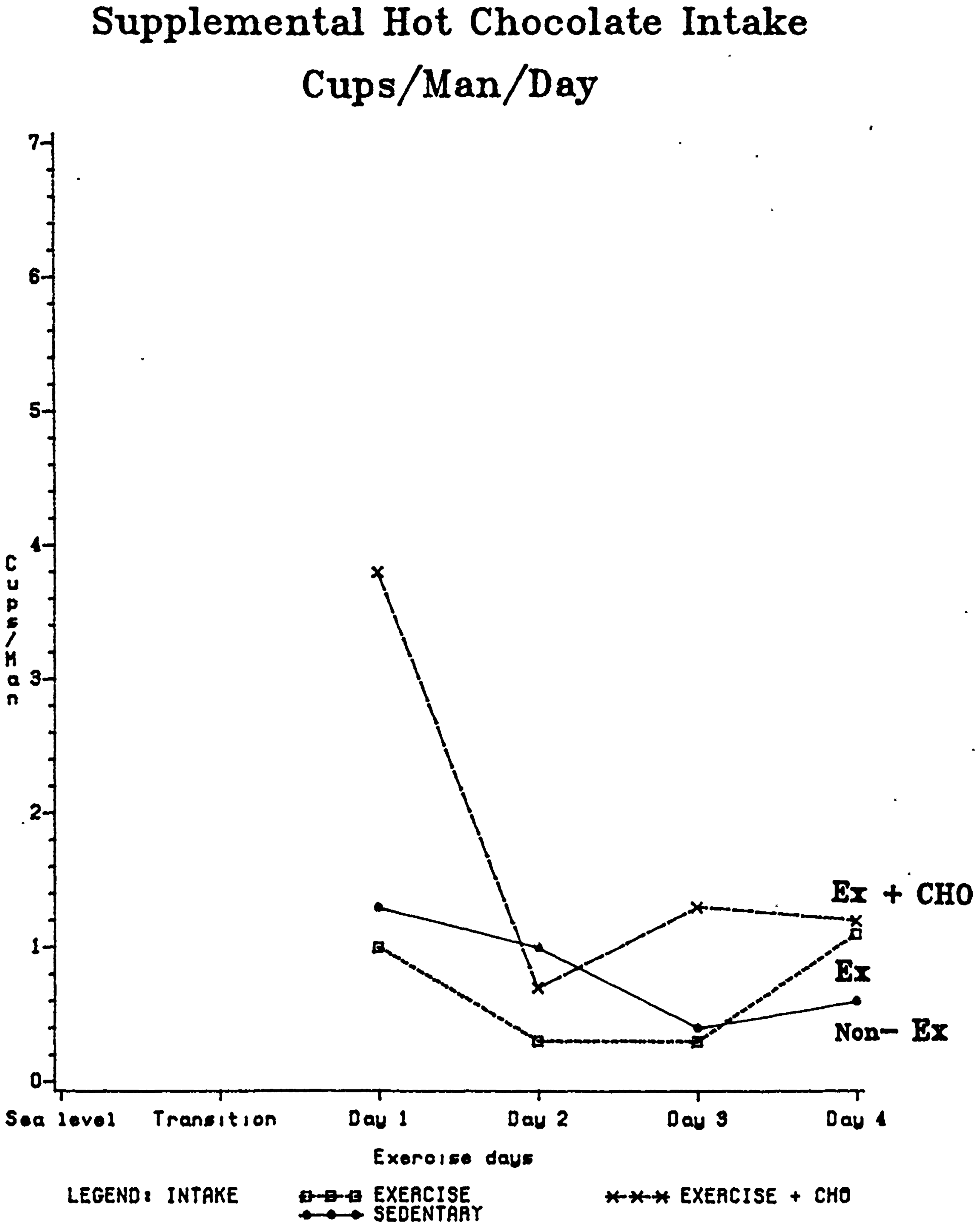

Supplemental Hot Chocolate Intake
Cups/Man/Day
Cups/Man
7
6
5
4
3
2
1
0
Ex + CHO
Ex
Non- Ex
Sea level
Transition
Day 1
Day 2
Day 3
Day 4
Exercise days
LEGEND: INTAKE
EXERCISE
EXERCISE + CHO
SEDENTARY

Figure 2

MRE Hot Chocolate Intake

Cups/Man/Day

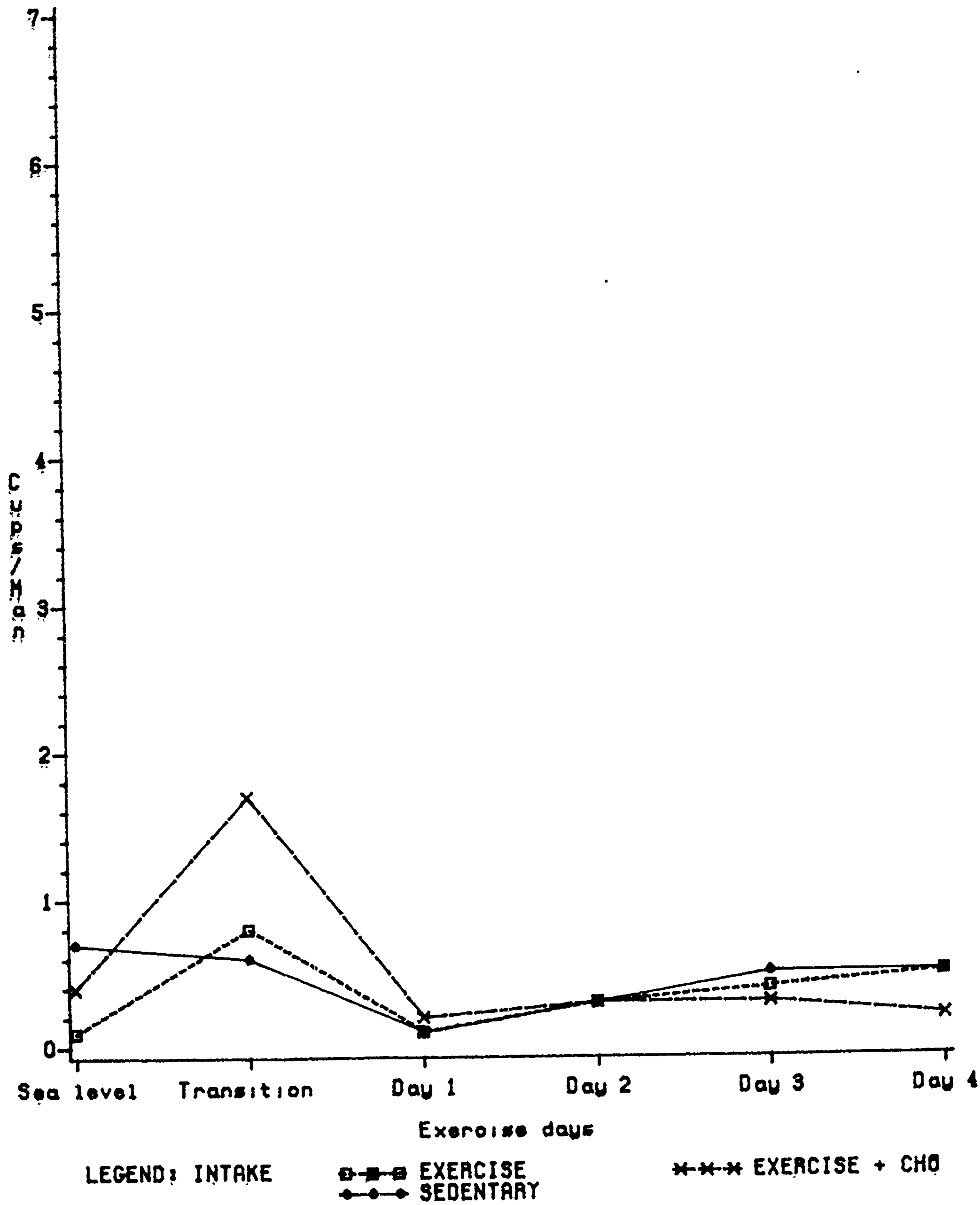


Figure 3

Table 1
Group B: Mean Daily Intake of Carbohydrates for Each Day
Supplemental Compared to Other Sources

EXERCISE + CHO		DATE				
		16JUL	17JUL	18JUL	19JUL	20JUL
		CHO, g	CHO, g	CHO, g	CHO, g	CHO, g
SOURCE						
Hot Choc + Polycose	Mean Intake	-	-	168	161	28
	% Total CHO	-	-	32.6	38.4	7.1
Kool-Aid + Polycose	Mean Intake	102	138	138	186	246
	% Total CHO	41.4	36.5	26.8	44.3	62.0
Other Food Sources	Mean Intake	144	240	209	73	123
	% Total CHO	58.6	63.5	40.6	17.3	30.9
Total All Sources	Mean Intake	246	378	515	420	397
	% Total CHO	100.0	100.0	100.0	100.0	100.0

Table 2
Group B: Mean Daily Intake of Carbohydrates for Each Day
Supplemental Compared to Other Sources

EXERCISE + CHO		DATE	
		21JUL	22JUL
		CHO, g	CHO, g
SOURCE			
Hot Choc + Polycose	Mean Intake	56	49
	% Total CHO	13.6	12.6
Kool-Aid + Polycose	Mean Intake	222	204
	% Total CHO	53.9	52.7
Other Food Sources	Mean Intake	134	134
	% Total CHO	32.5	34.7
Total All Sources	Mean Intake	412	387
	% Total CHO	100.0	100.0

Table 3
Group B: Mean Daily Intake of Calories for Each Day Supplemental Compared to Other Sources

EXERCISE + CHO		DATE				
		16JUL	17JUL	18JUL	19JUL	20JUL
		K CALORIES	K CALORIES	K CALORIES	K CALORIES	K CALORIES
SOURCE						
Hot Choc + Polycose	Mean Intake	-	-	744	713	124
	% Total KCAL	-	-	24.7	31.5	5.4
Kool-Aid + Polycose	Mean Intake	408	552	552	744	984
	% Total KCAL	22.5	19.8	18.3	32.9	42.9
Other Food Sources	Mean Intake	1408	2233	1717	805	1185
	% Total KCAL	77.5	80.2	57.0	35.6	51.7
Total All Sources	Mean Intake	1816	2785	3013	2262	2293
	% Total KCAL	100.0	100.0	100.0	100.0	100.0

Table 4
Group B: Mean Daily Intake of Calories for Each Day
Supplemental Compared to Other Sources

EXERCISE + CHO		DATE	
		21JUL	22JUL
		K CALORIES	K CALORIES
SOURCE			
Hot Choc + Polycose	Mean Intake	248	217
	% Total KCAL	10.0	9.6
Kool-Aid + Polycose	Mean Intake	888	816
	% Total KCAL	35.7	36.2
Other Food Sources	Mean Intake	1353	1222
	% Total KCAL	54.4	54.2
Total All Sources	Mean Intake	2489	2255
	% Total KCAL	100.0	100.0

Table 5
Group B: Mean Daily Intake of Carbohydrates for Each Period
Supplemental Compared to Other Sources

EXERCISE + CHO		PERIOD	
		Period I, Sea Level	Period II, Exercise
		CHO, g	CHO, g
SOURCE			
Hot Choc + Polycose	Mean Intake	-	74
	% Total CHO	-	18.2
Kool-Aid + Polycose	Mean Intake	120	215
	% Total CHO	38.4	53.1
Other Food Sources	Mean Intake	192	116
	% Total CHO	61.6	28.7
Total All Sources	Mean Intake	312	404
	% Total CHO	100.0	100.0

Table 6
Group B: Mean Daily Intake of Calories for Each Period Supplemental Compared to Other Sources

EXERCISE + CHO		PERIOD	
		Period I, Sea Level	Period II, Exercise
		K CALORIES	K CALORIES
SOURCE			
Hot Choc + Polycose	Mean Intake	-	326
	% Total KCAL	-	14.0
Kool-Aid + Polycose	Mean Intake	480	858
	% Total KCAL	20.9	36.9
Other Food Sources	Mean Intake	1820	1141
	% Total KCAL	79.1	49.1
Total All Sources	Mean Intake	2300	2325
	% Total KCAL	100.0	100.0

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